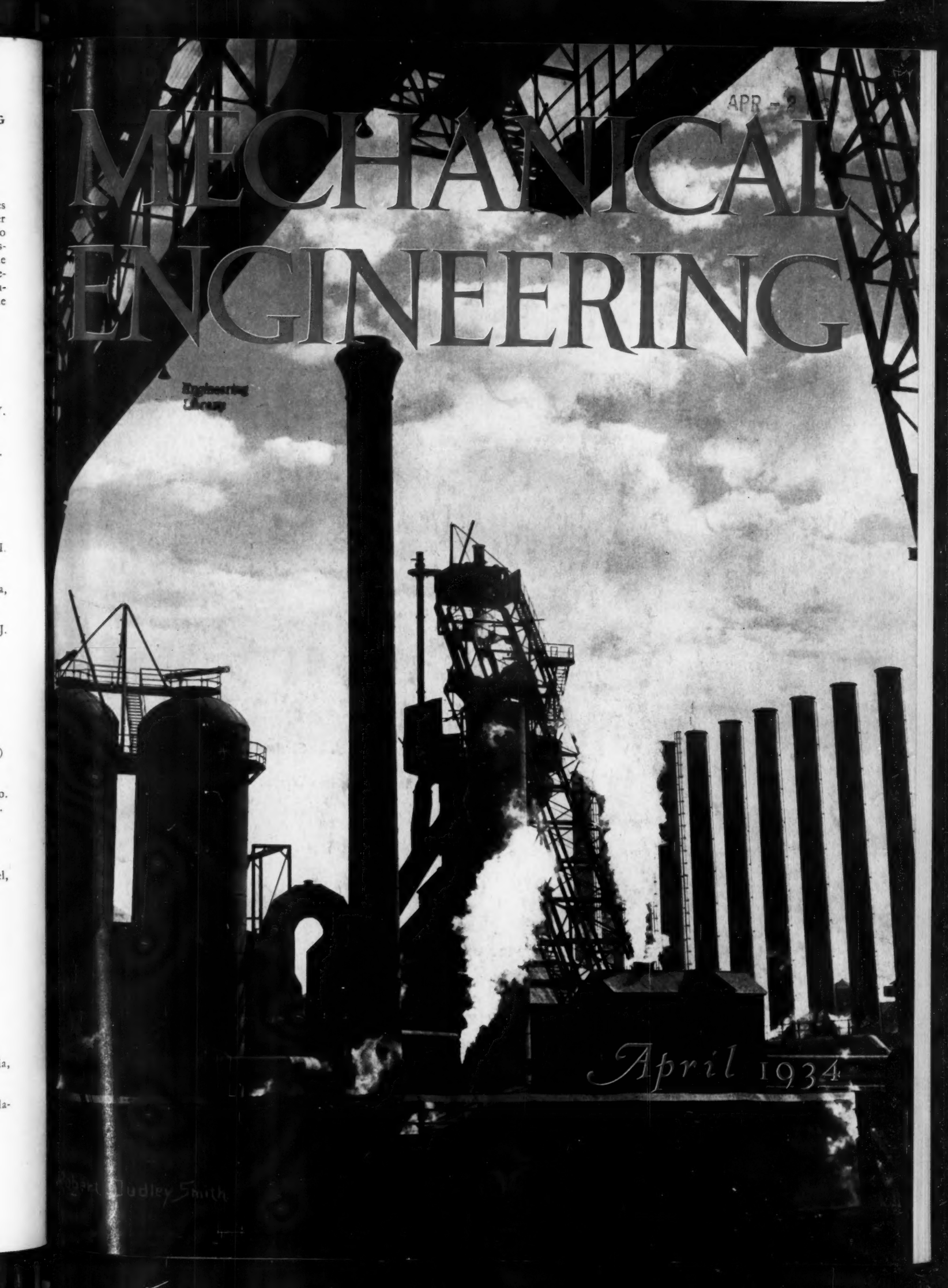
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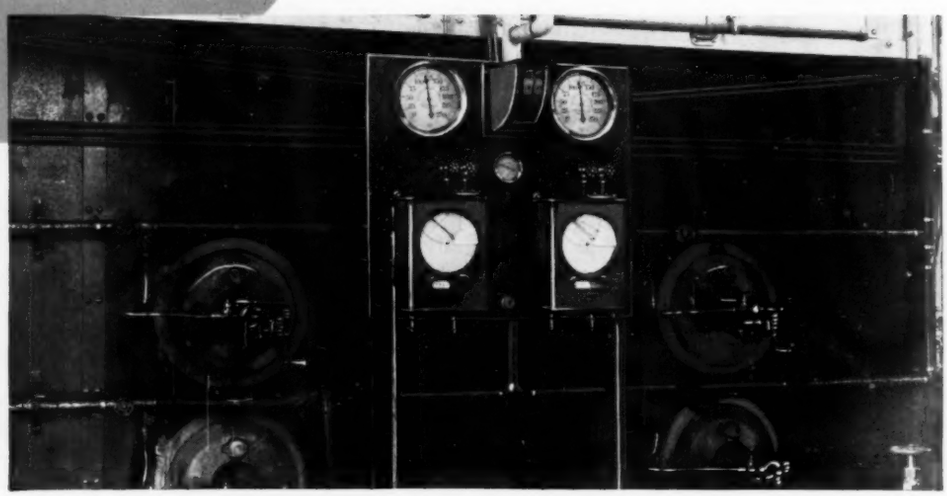

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The Machine Provides the Brawn—The Skill of Operation Is in the Perfect Coordination of the Hands and Brains of a Group of Men

INDUSTRY *and* AGRICULTURE *in the* TENNESSEE VALLEY

A Mutually Complementary Development as a Basis for a Stable Civilization

By W. R. WOOLRICH[1] and JOHN P. FERRIS[2]

THE ENTIRE world is searching for new ways of living which will yield to individuals both greater freedom and greater security than an unplanned order has permitted. Industrialized peoples cannot hope to build a stable civilization providing higher standards of living until they find means of relating industrial and agricultural enterprises so as to support a desirable distribution of population and income among city, village, and farm.

A new geographical distribution alone, however, is not sufficient. Our present farm crops could be supplied by several million fewer people than lived on farms in 1929 at the level of productive efficiency then existing. The proportion of our population engaged in agriculture decreased steadily between 1870 and 1930 from 180 per thousand to 84 per thousand. Owing to a sharp decrease in the proportion engaged in manufacturing between 1920 and 1930, the total proportion employed in the major activities decreased, as shown in Fig. 1. Definite increases in manufacturing production per man and per man-hour during the decade of 1920–1930 have been accelerated during the last three years.

It appears improbable that all of the two or three million people who have been forced by unemployment in the cities to retreat to rural areas and add their presence to the already large surplus of rural population during the last three years will return to urban industry. The reemployment of even the present unemployed in the great cities is a colossal challenge to business and government. As industry and agriculture are now organized, millions of people are not needed by agriculture and more millions are not needed by industry.

How are these people to live?

From 1800 to 1930 there occurred in the United States a great and little-noticed change in the distribution of population. The proportion of our people living on farms decreased from 85 to 23 per cent, as shown graphically in Fig. 2.[3] From 1920 to 1930 alone nearly six million people migrated from farms to cities. As the concentration of population in the great cities has become more intense, "the social distance between human beings increases so that the art of living and the business of making a living have come into intense conflict."[4] We are paying too great a social price and too great an economic price for our congested centers of population, which have become top-heavy and socially explosive.

A solution of this problem on a nation-wide basis is being sought through the organization of industries under the NRA, through the agricultural adjustment program, and through other measures affecting the total volume of goods produced, hours of labor, payrolls, and the distribution of total income as between industry and agriculture, and as between consumption and investment. However, it is possible that the American people will not support the permanent application of some of these measures, such as the subsidy of the one-quarter of our population which lives on farms by the three-quarters which does not. Other methods of balancing industry and agriculture must be investigated and tried.

The Tennessee Valley Authority has been specifically instructed to determine whether progress toward the economic and consequent social adjustment of industry and agriculture can be realized through a *closer physical association* between manufacturing and farming within a natural region, and to make demonstrations in which small manufacturing plants in rural areas give employment to surplus agricultural population and supplement inadequate farm income with income from industry. This involves finding the methods by which such a pattern of industry and agriculture can be realized within the framework of our present system of private investment in industry.

Fortunately, this development is not entirely new, but it has been forecast from time to time during the last twenty years in the thinking of various industrial leaders and economists, and is the continuation of trends toward industrial diffusion which have actually occurred in various parts of the country.

PAST DEVELOPMENT

The economic, social, and political conditions existing during the period of settlement of the Tennessee Valley

[1] Agricultural-Industrial Division, Tennessee Valley Authority. Professor of Mechanical Engineering, University of Tennessee (on leave of absence). Mem. A.S.M.E.

[2] Agricultural-Industrial Division, Tennessee Valley Authority. Assoc-Mem. A.S.M.E.

[3] "Economic and Social Effects of Urbanization," by Arthur L. Pollard, MECHANICAL ENGINEERING, January, 1933, pp. 27 to 31 and 60.

[4] "Let the Cities Perish," by Carol Arnovici, *Survey Graphic*, October, 1932.

discouraged a well-coordinated development of agriculture, industry, and commerce for which the area is so well fitted. The agriculture of the region was established upon a highly individualistic self-supporting basis with little thought of its relation to the future development of industry based upon abundant natural

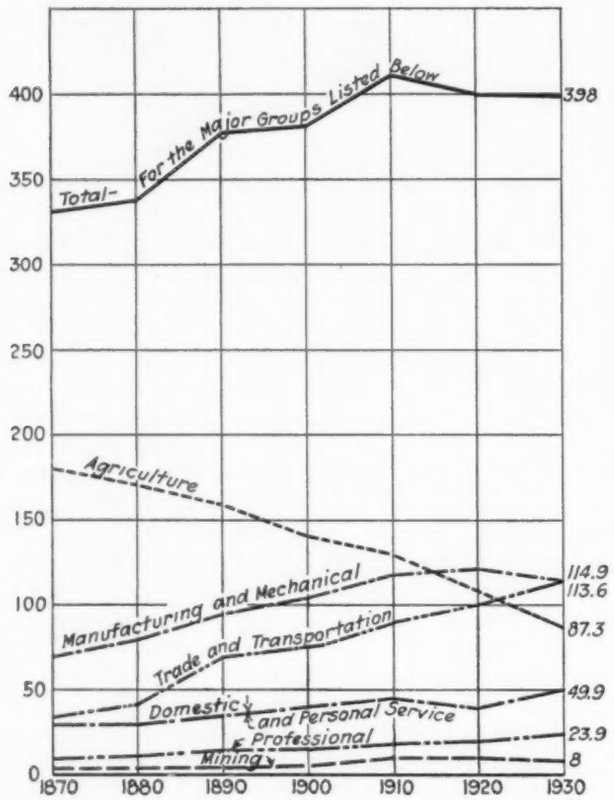


FIG. 1 GAINFUL WORKERS PER 1000 POPULATION IN THE UNITED STATES

(Charts prepared by the National Industrial Conference Board from census data, reprinted with permission. Curve of total computed from figures for individual groups.)

resources. As transportation facilities developed agriculture became more commercialized. Then it met keen competition from other regions in its major surplus products and was forced back upon a self-sufficient type of farming.

As population increased, and the fertility of the cultivated areas became exhausted the demand for new homesteads forced the clearing of remote new areas. During this period industries began to locate in the centers of population along the transportation lines and cities began a rapid period of growth unrelated to the rural areas from which they drew their population and raw materials. Gradually the rural counties dwindled in tivable wealth and were unable to support their schools, churches, and other social institutions. Some counties lost population, including the most enterprising and capable individuals, because there were no opportunities on the small farms. Those who remained depleted the soil and forests in order to support themselves.

Fig. 3[5] shows the effect of these forces upon population between 1920 and 1930. Of the nearly six million people who left the rural areas for the cities, a strikingly large proportion were from the southeastern states. Even after this migration, in typical rural counties of East Tennessee there are 1000 to 2000 people in each county who are not needed for agriculture.

A survey of one purely agricultural county in Tennessee (Grainger) in 1932 showed that Federal and state tax payments going into it were $91,000 in excess of tax revenue produced there; that the county buildings depreciated $80,000 during the year; that depletion of soil and forests was about $55,000. A county trade balance was struck, including flow of commodities in and out and of cash in and out; the result was a $212,000 deficit. The income from commercial agriculture was utterly inadequate to maintain anything approaching a satisfactory standard of living for the people of such counties. Only an increased subsidy from state and Federal Government or the supplementing of agricultural income from some industry can provide it.

In his "Human Geography of the South," Vance points out that, with one quarter of the nation's population, eleven southeastern states must rear and educate half of all our farm children, so that the relative burden of rural education is far higher than in other areas.

Referring further to Grainger County, Fig. 4[6] shows how lack of economic opportunity affected age distribution in this same county. There was a larger proportion of people below 21 than the average for the United States. There was a far smaller proportion of people from 21 to 52, and about the same proportion of people older than 52. In other words, large numbers of people in the prime of life had gone elsewhere to seek a living; and a correspondingly large number of people above working age had returned after they had been thrown on the human scrap heap in the cities.

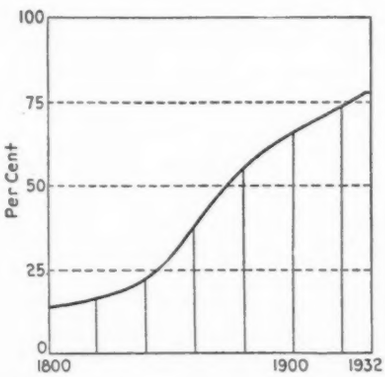


FIG. 2 URBANIZATION IN THE UNITED STATES—PERCENTAGE OF POPULATION NOT ON FARMS

Farmers whose income came partly from agriculture and partly from industry were more fortunate than those dependent entirely on agriculture, as indicated by Fig. 5.[7] This chart compares the net labor incomes, including both cash and commodity items, of 32 similar farm families, half of which had part-time work other than on the farm. (In 1929, about 30 per cent of all

[5] Bureau of Agricultural Economics, U. S. Department of Agriculture.

[6] Arthur L. Pollard, Knoxville, Tenn.

[7] J. C. McAmis, Tennessee Valley Authority.

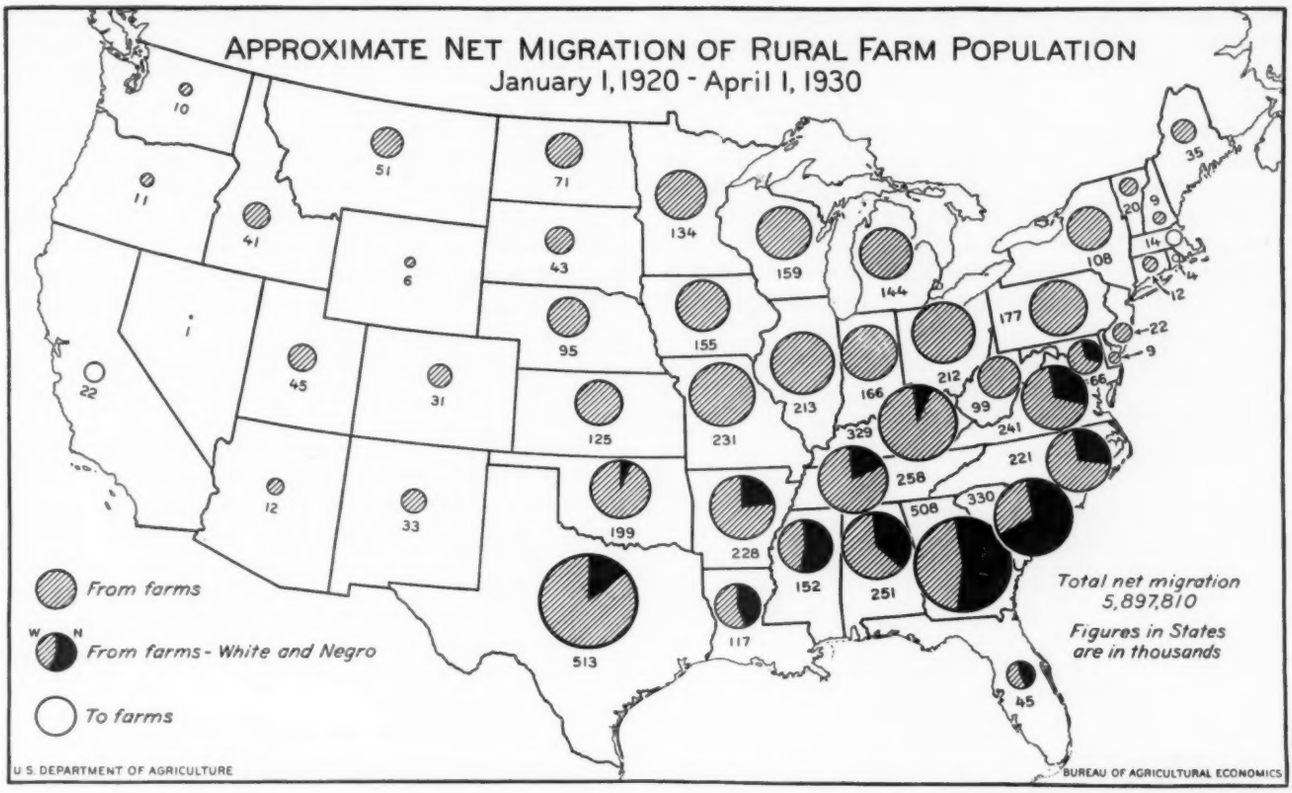


FIG. 3 APPROXIMATE NET MIGRATION OF RURAL FARM POPULATION (JAN. 1, 1920–APRIL 1, 1930)

the farm operators in America did some work for pay on roads, in forests, in industries, and other non-farm occupations. About 11 per cent worked 100 days or more at such occupations during the year.)

THE FORCES AT WORK

Industry became centered initially in congested areas during the last one hundred years due largely to three fundamental conditions: First, the necessary power was available only in the larger centers to which coal could be hauled cheaply. Second, quick communication, ready access to raw materials, and the shipment of finished products required a location on the few main railroad arteries, or near seaports. Third, inadequate transportation for the workers forced them to live close to the factories.

The availability of electric power in thousands of small cities and in rural areas all over the country removes the first of these limitations, and modern transportation is rapidly removing the other two.

Electric power, improved rail and water transportation, hard-surfaced roads, automobiles, motor trucks, and the telephone are not *causing* the spreading out of industry, but they are *permitting* it.

The principal economic "centrifugal forces" which are exerting a pressure upon industry to diffuse are as follows (some of them are at work in one industry, some in another):

Lower operating costs in smaller cities, due to lower labor costs, lower rents and taxes, etc.

More efficient distribution of the product from plants located near their markets.

More efficient management in organizations of moderate size. In many industries smaller units are most efficient.

Greater flexibility and adaptability of organizations of relatively small size.

There are also sociological "centrifugal forces" which are pushing industry out from the center. There is "a growing concern for the welfare of workers and the increasing realization of the menace to society . . .[of] large numbers of workers being thrown out of employment with no . . . means of support. . . . uncomfortable and bad living conditions prevalent in highly populated areas impair the health of employees."[8] There are also the social instability of large cities and the existence of racketeering and various municipal restrictions.

While twenty years ago only owners and a few officials in manufacturing plants could live outside the cities, today in many communities large groups of workers are showing a desire for homes in the country. This desire for more spacious living conditions is another effective sociological force in this direction. There are instances in which this force prevented the building of southern mill villages.

RECENT INDUSTRIAL DEVELOPMENT IN THE TENNESSEE VALLEY

Industries developed in the northeastern United

[8] Harold V. Coes, in New York *Times*, October 9, 1932.

States largely before the day of the hard-surfaced road, automobile, truck, telephone, and electric power in the small communities.

Fortunately for the Tennessee Valley area, much of its industrial development has taken place since these new forces have been at work. When Dr. H. A. Morgan began about ten years ago to investigate the future possibility that industry might give income to surplus rural population and make possible well-balanced agricultural industrial communities, it was found that a very considerable development in this direction had already taken place. Communities had grown up around such towns as Kingsport, Greeneville, and Elizabethton, where the workers owned small tracts of land several miles from the plant and drove to work

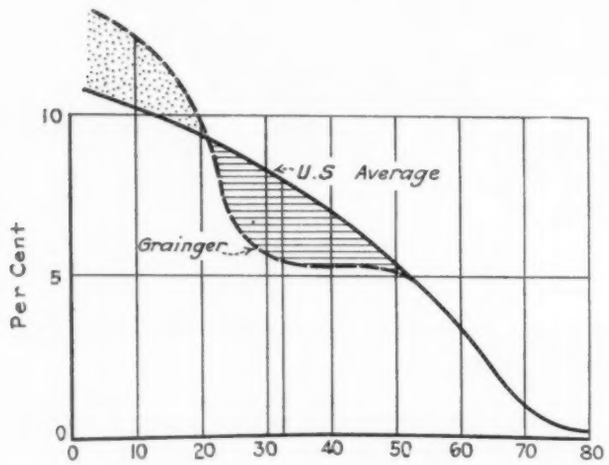


FIG. 4 AGE DISTRIBUTION—UNITED STATES AVERAGE AND GRAINGER COUNTY

each day. In some of these cities, we find 25 to 75 per cent of the operators living in rural sections. In Kingsport, the average distance of the rural worker from the plant was 8.4 miles. Thus, there was a linking of agriculture and industry in a way that is not common in the North. It is, of course, questionable whether in the extreme northern areas this relationship is as workable as in our southern areas, since many of the northern roads become impassable during the periods of heavy snow-storms.

THE ECONOMIC NECESSITY FOR INCREASED EMPLOYMENT IN INDUSTRY RELATIVE TO EMPLOYMENT IN AGRICULTURE

Our foods and fibers could be produced by many fewer people than are now on farms. There exist "surplus"[9] farm production and "surplus" farm population, and these "surpluses" have depressed farm prices until the economic standard of living of almost the entire farm population has fallen very low.

The people of the cities have not in the long run profited from this maladjustment, as the wheels of industry and commerce have slowed down so far that most city dwellers are also suffering privations. Even those who still have large incomes have no security.

In general, consumption of food is definitely limited, while the consumption of industrial goods is unlimited. As farm production rises, some of the farm people must shift their economic support from commercial agriculture to industry or commerce or to raising products for which there is an untapped demand. That this has been happening from 1870 to 1930 was shown in Fig. 1. Unfortunately, many rural areas lost their most enterprising and capable individuals in the migration to find economic opportunity in the cities. As rural people left the land, they exchanged the assurance of at least subsistence security for complete dependence on the pay check.

During past periods of business expansion, the pay check has given some security; during past depressions, the industrial unemployed have reached out to find security again in migrations to land on the distant frontier.

The inflexibility of demand for farm products and the difficulty in controlling the supply make it necessary and desirable for more people to work in industry and fewer in agriculture.

THREE POSSIBLE METHODS OF ADJUSTMENT

Large numbers of people now in rural areas must find industrial employment. The question is what kind of industrial employment is to be provided, and what kind of living and social conditions will accompany it.

The way of the past has necessitated the migration of rural people to the cities. The excessive urbanization of population in the past, however, has not been successful. Many of the farm people who have gone to the cities to get income from industry have found attractions not generally available in rural areas but have been disappointed by squalor, narrow lives, and desperate insecurity. If the excess rural population is forced to the cities it must be supported as a public charge when industry and commerce fail to provide employment. Furthermore, mankind does not yet know how to manage large cities successfully. Probably some of our largest metropolises should be encouraged to grow smaller rather than larger.

Another way is to create subsistence communities in which unemployed farmers (or city dwellers) grow food for their own consumption but, in order to avoid adding to crop surpluses on the markets, not for cash sale. Such commodities must be subsidized in some way in order to provide cash for taxes, purchase of land, and various goods which cannot be produced in the communities themselves.

The third way is to introduce industrial production and employment at points accessible to the "surplus" farm population. In this manner their economic support can be partly transferred to industry without making it necessary to abandon entirely the rural way of living and the security that goes with it.

Small industries in rural areas can supplement farm income by part-time industrial employment; they can

[9] Surplus is here defined as a supply greater than can be sold at a price sufficient to maintain normal exchange between farm and industrial producers.

offer full-time employment to rural people with no farm income; some of them can provide nearby markets for farm and other local products as raw materials; some of them can be organized on a cooperative or membership basis which will tend to prevent the draining of purchasing power to other areas through dividends, interest, and rent payment; and often they can serve nearby markets more efficiently than highly organized large industries; some of them can develop products characteristic of the region, based on local skills, and thus help to preserve the individuality of their regions.

In addition to the desirable effects of industries located in rural areas upon the life in these areas, there are reasons for believing that it is important to our civilization as a whole that means be found to provide this essential employment in industry and associated occupations in rural areas. Some of these reasons are here listed:

(1) Communities which are not too crowded and not too far removed from the land and the natural processes of growth around which life is organized in rural areas can offer the best background for the children of each oncoming generation.

(2) The advantages of rural life can be preserved in the border industrial-agricultural communities, and the disadvantages of isolated living largely overcome through better planned rural communities with homes grouped along good roads, through rural electrification, and through the rebuilding of small cities in rural areas into real centers of social life.

(3) As long as food and other products must be grown on the land, we must have an agricultural population. Because of the conditions of farm living, the bargaining power of people on land will tend to be low. Good schools, high-grade medical and social services, and good facilities for recreation have always followed wealth, because wealth has been necessary to sustain them. They have therefore been found in centers of population to which industry and allied activities gave a high bargaining power. If, as stated above, the artificial subsidy of farm production on a permanent basis is impractical, then rural people will have good schools, high-grade medical and social services, and good facilities for recreation only if the agricultural production can be organized around outlying centers of population to which a part of the nation's industrial production bring a flow of purchasing power.

(4) No large city population has ever maintained itself. The rural areas have always produced, reared, and educated more than their share of children. It is essential for the welfare of the race that the rural communities furnish the necessary social background to do a good job of training the oncoming generations.

(5) The security against periods of unemployment due to fluctuations in industrial activity which is furnished by a home located on the land is a more satisfying and less wasteful security than that furnished by cash unemployment compensation through periods of idleness.

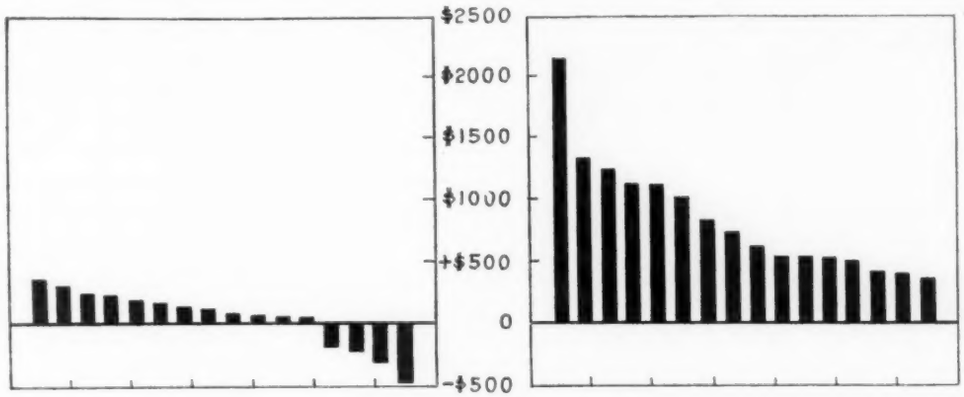


FIG. 5 INCOMES OF 16 FULL-TIME FARMERS (LEFT) AND 16 PART-TIME WORKERS (RIGHT)
(Each upright line represents the income of one family for the year 1932.)

DIVERSITY OF INDUSTRIES

Not all types of industry, of course, are adapted to operation in rural areas and not all are independent enough of locations of materials, markets, and specialized labor to be capable of operating at given points of "surplus" rural population. However, light manufacture of many kinds, including textiles, food products, clothing, paper and printed products, etc., have shown themselves surprisingly free in choice of location. Even some leading machine-tool plants are located at rather inaccessible places and have operated successfully there for decades.

Many people have considered in recent years that the day of small industries was past; that soon there would be only very large industries with the probable exception of a varied list of what Dr. A. E. Morgan characterizes as "peanut stands." But many a "peanut stand" has shown itself better able to adjust to recent conditions of rapid change accompanying the depression than some of our larger industries. Not infrequently investments in peanut-stand-size enterprises have paid dividends while investments in competing large-scale enterprises have been lost by default.

That the small factory is still important is indicated by the following facts: In 1925, 75.9 per cent of all American manufacturing plants used less than 100 connected horsepower; 96.4 per cent used less than 1000 connected horsepower; 22 per cent of the workers were employed in plants using less than 100 hp and 58 per cent in plants using less than 1000 hp.

A balanced industrial development will include large, medium, and small plants adapted to various fields of manufacture and to various locations. Some industries

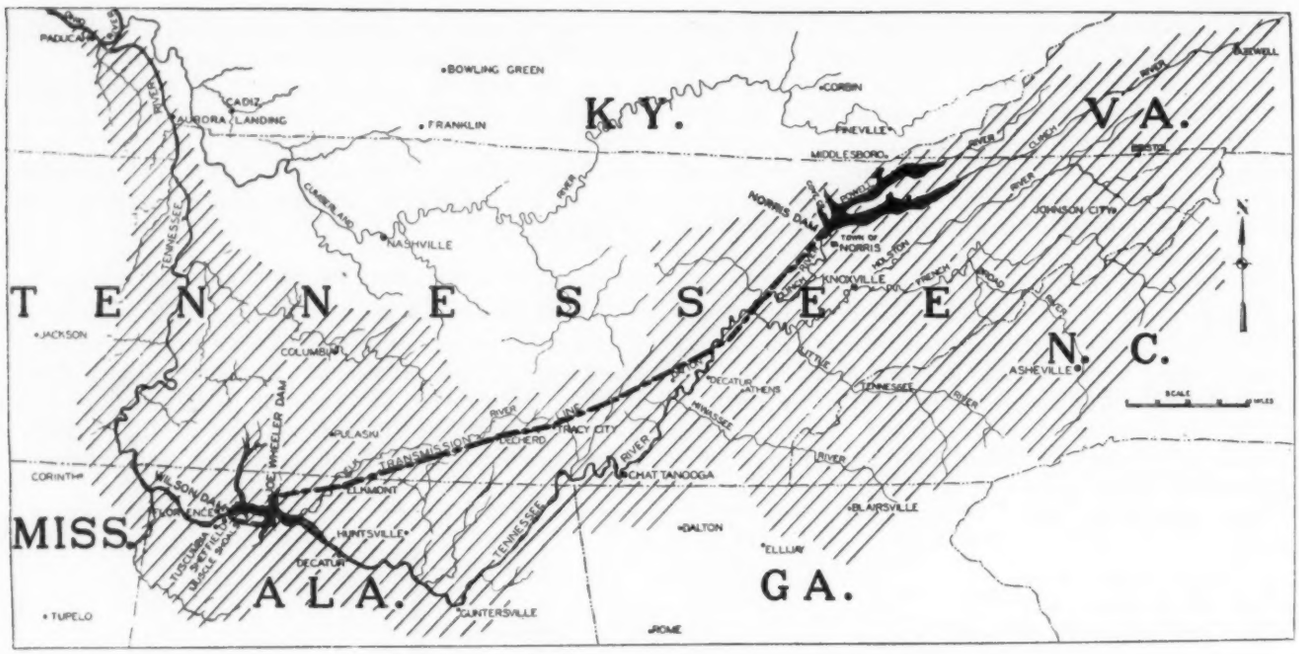


FIG. 6 GENERAL OUTLINE OF THE TENNESSEE RIVER BASIN

(Showing the site of the Norris Dam in relation to Muscle Shoals and General Joe Wheeler Dam and the route of the transmission line which will connect the three dams. The shaded area indicates the sphere of development by the Tennessee Valley Authority.)

are naturally large and operate more efficiently as large units. Ordinary steel and cement will continue to be made in large plants unless processes change. In the case of steel the need for assured supplies of ore and marketing considerations make for ever larger units and centralized control.

Clothing, good furniture, and many other products can be made as economically, or more economically, in plants of moderate size.

It begins to appear that phosphate fertilizers in certain parts of Tennessee Valley can be most economically mixed in peanut-stand-size plants near the points of use.

One advantage of small units is that many of the human factors involved in management are more quickly sensed and are thus more readily adjusted.

It is also to be noted that small plants do not necessarily imply small and financially weak organizations. Many of the small plants in America are branches operated by very large companies.

The topography of much of the Tennessee Valley area consists of alternate ridges and valley sufficiently broken up to form communities which tend to grow to a population of not more than ten thousand people. The industrial plant adapted to such a community is necessarily small.

While there are good roads connecting these local valley areas, tradition and other factors have resulted in preserving distinct differences in the character and activities of the people in these communities. In one such area, tobacco curing is a dominant activity; in another it is the manufacture of low-priced chinaware; in another there will be found an abattoir; and in only a few mass-production industries, such as rayon spinning, book printing, etc. There is a place in the Valley program for electrochemical and other industries using large amounts of electric power and local materials. Several of these enterprises under private ownership have asked for power contracts.

It appears that here is a natural setting for diversified industry—diversified both as to size of enterprise and as to character of product. The strongly individualistic bent of the people suggests it as a location for the production of individualized goods rather than of mass production. There is ample evidence that the people of the area pick up industrial skills quickly and that there is a largely untapped reservoir of talent in craft skills. Surprising artistic work comes out of isolated mountain communities, the productions of people who have had little economic opportunity and little training.

For the Tennessee Valley area to turn in this direction does not require a right-about-face. Due to the great diversity of climate, topography, and soils in this area, and due to its comparative isolation during the period in which the economic character of much of the United States was cast in the mold of mass production, this area was not cast in that mold; neither its agriculture nor its industry is characteristically of the mass-production type. If America is beginning to turn a little sick of too much mass production of goods, with the regimentation of life that goes with it, here is a setting for the manufacture of products of character and individuality.

There seem to be in all industries normal fluctuations in activity based on the periodic replacement of their products.[10] It appears improbable that these fluctuations could ever be eliminated by providing people

[10] "Rhythmic Variations in Industry," by Thomas M. McNiece, MECHANICAL ENGINEERING, November, 1933, pp. 659–666.

with continuous income, as their source is not failure of purchasing power. These fluctuations in different industries, however, are not in phase with each other, and the combined fluctuation is much less than that in any one industry. Obviously, the impact of the resulting periodic industrial unemployment in any given community is much less if the industry of the community is diversified. Quite independently of the recurrence of cyclic depressions, there should be shock-absorbing marginal areas in which industry and agriculture are carried on side by side, the same people deriving part of their income from each. While serious cyclic depressions may some day be eliminated, there is every prospect of a continued tendency for industry to fluctuate. Our entire social order will be more flexible if several hundred thousand of our gainfully employed people are engaged in both types of activities.

Unemployment-insurance funds mitigate the effects of periods of reduced employment in industry but do not eliminate the economic waste of lost effort; purposeless idleness is unsatisfying to the individual. The employees of industry in rural areas can have a better type of unemployment insurance than merely cash compensation, as they can live in homes on the land and can use time not needed in industry to improve their homes, grow food, and in other ways to raise their standards of living.

A community based on well-balanced industry and agriculture should include some large mass-production industries, turning out certain articles in large quantities very cheaply, but it should also include a diversity of smaller plants distributed among various industries. America needs industrial "peanut stands," and a great many other sizes and types of industry, all the way up to the "dinosaur" type.

SOME METHODS OF PROCEDURE

The methods adopted to bring about a realization of the objectives of the Tennessee Valley Authority must be as varied and adaptable as the multitude of economic factors in the mosaic of American activity. The public mind visualizes the major projects in the Tennessee Valley program as being power development, dam construction, and navigation improvement. But equally important in this regional plan are the diffusion of industry and agriculture, the better adjustment of the rural and urban population, the planned utilization of land to prevent further erosion and develop increased fertility, the conservation of mineral and forest resources; all this to be accomplished with the preservation of the social and religious values for which the area is noted.

Further, the assumed obligation of the Authority is that of providing not merely a demonstration of an improved region but a national exhibit of the development of a better type of American life.

Typical of the methods being used is the establishment of uniform power rates at all points along the transmission line from Wilson Dam to Norris Dam. The previously prevailing practise of offering better rate schedules at the points of power generation has encouraged concentration of industry. The new schedule offered by the Tennessee Valley Authority makes the many rural locations along the 230-mile transmission line just as attractive from the standpoint of power costs as locations near the power dams.

Again, the mixing of fertilizers with their high percentage of carrier content has customarily been carried on in large fertilizer plants. This has occasioned the payment of freight on large tonnages of these carriers that are very generally available anywhere in the Tennessee Valley. It is planned to do much of this mixing at outlying points to which the concentrated nitrates, phosphates, and potash are transported. Such a process will reduce the cost of plant food very materially.

BOTH PRIVATE INDUSTRY AND COOPERATIVE ENTERPRISES ARE INVOLVED IN THE DEVELOPMENT

This and many similar developments will be fostered both by private industry and by cooperative enterprises. To stimulate necessary investments in industries in rural areas will require going demonstrations showing in actual operation the proposed relation between industry and agriculture. The Tennessee Valley Authority is projecting such demonstration areas, some of them taking in two or more counties. The development of practical means of organizing and financing local industries in these demonstration areas and in other rural areas constitutes one of the most important tasks ahead. Cooperative industries may play an important part, but privately owned industry should do most of the job.

The Tennessee Valley Associated Cooperatives, Inc.,

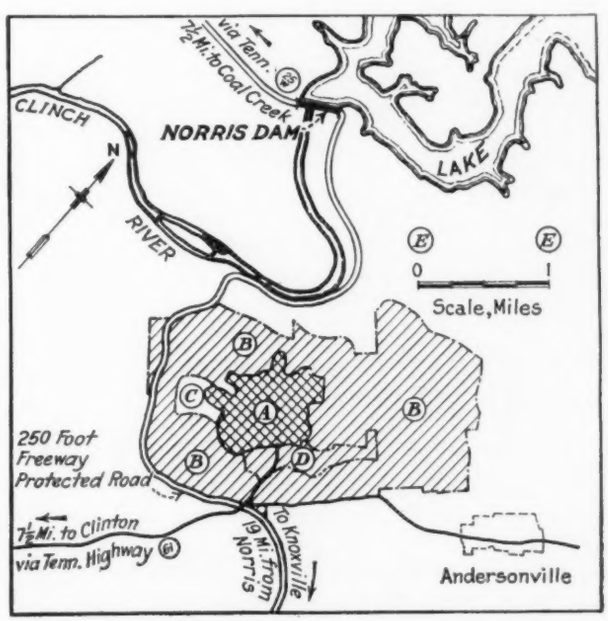


FIG. 7 TOWN OF NORRIS, TENN., AND ITS ENVIRONS (*A* = Town building area; *B* = Protective belt of gardens, pastures, and forests; *C* = Construction unit; *D* = Demonstration farm; *E* = Town forest.)

has been formed, and one of its purposes is to assist local people in setting up and financing industries in demonstration areas. The plans of organization contemplated are based on cooperative private ownership, with both private and public loans for initial financing, full ownership and control ultimately to be transferred to members. It will have a central advisory and accounting service available to cooperatives in the group.

The entire program imposes the necessity for a well-ordered research development. The early emphasis for research study in American came largely from the scientists of Europe who took refuge on American soil and adopted this country as their home. It is an all too-well established fact that the northern areas selected by these immigrant scientists for their adopted homes was also the area most productive of scientific discovery. Southern scientific and technical research laboratories have only come into their own within the past two decades and now give promise of some genuine contributions to American life.

Many southern products hold future promise for industrial development. Sweet potatoes, hemp, fiber flax, sorghum cane, cotton seed, southern fruits, southern pines, cedar, pecans, walnut wood, aluminum, magnesium, phosphates, and manganese are among those products of immediate prospect.

Not only is the Tennessee Valley Authority itself carrying on some of these researches to speed up actual production, but the laboratories of all the southern states related to the Valley, especially the agricultural and engineering experiment stations, are being invited into the picture to encourage a pooling of brains to help develop the possibilities of such materials. The products of these research investigations are then to be projected into the manufacturing program in the Valley.

The cooperation of the rural people of the Valley is being solicited through their established public agencies upon which they depend for research, instruction, and demonstrations in the basic principles essential to the orderly use of their resources to support a permanent rural civilization. The farm people and the agencies representing them are being asked to pool their facilities, experience, and energies in a program of adjustment of their farming practises so as to conserve the soil, water, and timber resources of the farms and to protect the power of the streams for the use of a balanced agricultural-industrial society.

TENNESSEE VALLEY GEOGRAPHICALLY FAVORABLE

Fortunately, the Tennessee Valley is in a very desirable geographical position to carry on a planned development of the area. It lies in the pathway of a large portion of northward and southward movement of products, just as Ohio was a transit state for the people going West from the eastern states. Then three-fourths of the American people had to pass through the state of Ohio if they took part in the western development; so we find now that a large proportion of the people travel through the Tennessee Valley area in participating in northern and southern commerce.

That the new training of the residents of the area should come largely by their own cooperative enterprise is fundamental to the success of the project. The organization of cooperatives requires their participation in the development and gives training in the principles and operation of the plan.

And in such a cooperative association, the industrial worker will receive some of the privileges of ownership which he has slowly seen passing from his grasp in the movement from craft trades to mass production. That this may be accomplished without returning to the drudgery of hand production is a desirable consideration.

THE NATIONAL SIGNIFICANCE OF THE TENNESSEE VALLEY EXPERIMENT

The definite goal of the Tennessee Valley Authority is that those projects involving the physical development of the area shall be self-liquidating, this to include projects financed by the Government as well as by private funds. The fertilizer, the power, and the agricultural-industrial programs, which are absorbing by far the major part of the initial Federal investment, are all based on this principle.

There have been indications that people in other parts of the country regard the Tennessee Valley development as a purely sectional matter, a sort of present to the area. Every section of the nation is in urgent need of patterns and working principles by which agriculture and industry can play balanced rôles in bringing a more fruitful life.

The economic necessity for increased employment in industry relative to employment in agriculture exists in all industrialized areas, and surplus rural population throughout the country is faced with the following possibilities:

(1) Accept a still lower standard of living below a tolerable minimum.
(2) Live wholly or partly by some form of public aid.
(3) Find a means of obtaining some income from industry or associated occupations.

The absence of facts upon which any national program for the solution of this problem could be based, was one of the reasons for setting up an experimental region within the nation from which results applicable to the entire nation might be obtained. This particular region was chosen because it was peculiarly adapted for the experiment.

This project is fundamentally a search for facts and a demonstration of working principles upon which national programs might be based. It points the way for the adjustment of population as between industry and agriculture, and it suggests a method by which the liberties of individuals can be preserved for this and future generations. There is no field in which such facts and demonstrations are more urgently needed, both by this region and by the nation.

What PSYCHOLOGY CAN CONTRIBUTE *to* *Industrial* STABILITY

By RENSIS LIKERT[1]

NO FIELD of psychology in recent years has developed as fast or promises as much for the immediate future as that concerned with personality and the dynamic factors back of our everyday behavior in face-to-face contacts. It is toward the significance of these developments for management that I wish to direct attention.

There is an essential difference between men and machines which we often mention glibly but which all too frequently we fail to observe in practise. I refer here to the fact that men are not only acted upon, that is, managed, but that they also *react*, and their reactions are a fundamental factor in every industrial situation. Machines on the other hand are only acted upon.

Whenever and wherever we are dealing with men we must recognize that they are not passive agents but highly dynamic organisms whose response to treatment may completely alter the existing or expected situation. And yet how often this apparently obvious statement is not realized. We are all familiar with incidents where the workman's response to conditions imposed upon him have completely changed the situation that management expected to produce. A recent illustration is the effect of the minimum-wage provision of the NRA codes. It was expected that this provision would reduce industrial unrest. Actually, however, there is evidence that it has increased it. Workmen who obtained satisfaction in the differential existing between themselves and the lowest paid of the workers about them, suddenly had this differential removed or considerably reduced. This proved to be a blow to their self-satisfaction and resulted in no small amount of irritation and unrest.

That men *react* to the treatment they receive is on the whole important only if we recognize as fundamental the fact that that morale which is the basis of effective cooperation and teamwork is absolutely essential for efficient production as well as pleasant industrial relations. If production and efficient operation could be maintained regardless of the treatment accorded men, then their reactions to the way they are managed would be important only with respect to human happiness. Fortunately, it seems clear that morale and genuine cooperation are essential for efficient operation and that those factors which make for the happiness of the workers also result in the desired morale. The importance of good morale and cooperation is, I believe, being increasingly accepted. Certainly, a number of recent studies such as those of Mathewson[2] and of Putnam[3] and Pennock,[4] have clearly demonstrated the necessity of effective morale to achieve anywhere near optimum production. Its importance is also recognized and stressed by Mogensen in his emphasis upon what he calls the new approach in the application of motion study.

Accepting the fact, then, if we may, as amply demonstrated and increasingly recognized that favorable morale is necessary for the proper functioning of our industrial system, let us examine some of the more important aspects of the process governing man's reactions. To control, that is, to manage, the behavior of men in an industrial or any other situation we must understand this process.

MAN'S BEHAVIOR NOT RATIONAL

That man's behavior is not rational, at least not in terms of the more apparent aspects of a given situation, we must accept as fundamentally basic. For example, you cannot accurately predict how a man is going to vote by making a rational analysis of the apparent facts in a given situation. No more can you understand, predict, or control the behavior of workmen in industrial situations if you know only a few of the obvious facts concerning them. We have all seen an individual or a group of individuals do something which, rationally, was manifestly to their detriment. In fact, we even speak of a person's "biting off his nose to spite his face." Such conduct is only understood when we are aware of all the forces, obvious and otherwise, which are controlling the individual's behavior. Man's behavior is dynamic and is expressive of all the forces,

[1] Assistant Professor of Psychology, College of Engineering, New York University, New York, N. Y.

Contributed by the Management Division and presented at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[2] Mathewson, S. B., "Restriction of Output Among Unorganized Workers," Viking Press, 1931.

[3] Putnam, M. L., "Improving Employee Relations," *Personnel Journal*, vol. 8 (1930), pp. 314–325.

[4] Pennock, G. A., "Industrial Research at Hawthorne," *Personnel Journal*, vol. 8 (1930), pp. 296–313. Pennock, G. A., and Putnam, M. L., "Growth of an Employee Relations Research Study," *Personnel Journal*, vol. 9 (1930), pp. 82–85.

Galloway, N. Y.

"MEN ARE NOT ONLY ACTED UPON, THAT IS, MANAGED, BUT THEY REACT, AND THEIR REACTIONS ARE A FUNDAMENTAL FACTOR IN EVERY INDUSTRIAL SITUATION"

desires, wishes, motives, habits, fears, and ambitions which are harbored within him.

You will notice that I wish to include not only the traditional "instincts" but particularly the much more complex and important forces which we call attitudes, sentiments, loyalties, feelings of inferiority, of insecurity, and other similar emotional patterns which have been built upon the fundamental, innate motives of men. The so-called "instincts," which previously have been emphasized as affording a basis for understanding the behavior of men in industrial life, we now recognize as being totally inadequate for that purpose. The reactions of men are much better understood when we recognize the importance of these more complex patterns in determining behavior. It is significant to note that these complex patterns such as loyalty to a union or a religious sect are considerably influenced in their formation by environmental factors and hence to an appreciable degree subject to managerial control.

In industry to attempt to understand and control the behavior of a workman when all we know about him are a few superficial facts about the deeper lying forces such as attitudes, emotional patterns, and motives present in his personality is as ridiculous as a physician's noting the rash at the onset of scarlet fever and attempting to clear it by a skin ointment. And yet, by and large, are not we attempting to manage men when we know almost a minimum about them and the forces at play in their lives? How can we expect to understand and cope effectively with their reactions if we are entirely unaware of the forces which are largely determining those reactions?

Most employers and persons in managerial positions are all too ignorant of the real attitudes of their employees toward the various factors in their working life. Employers and managers, in general, are all too little informed about the way their employees really feel toward their foremen, their pay, the light, heat, and ventilation in the plant. They do not know what the attitudes of their workers, skilled and unskilled, clerical and otherwise, are toward the number of hours worked per week, the responsibility of the company for regular employment, and similar questions. Nor do they know whether the men are proud to work for the company and happy because of their association with it.

On the contrary, most managers' and employers' views are based on what they *think* is the case or what they wish were the case, rather than what they *know* to be the situation. The average employer sees the situation pretty much from his point of view, benevolent though it may be. And at best the glasses of the employer and the employee are of appreciably different colors. The average employer usually views himself as providing his men with a reasonable wage, pleasant working conditions, and often various other services for the benefit of his employees, such as medical care. Consequently, from his point of view he is often perplexed to understand why his men do not show the appreciation that he thinks they should for what he has done for them. Nor can he understand why they resent the welfare work he does, why they are willing to strike against him, why they deliberately and purposefully restrict output, whether it is an open or closed shop. And the employer will continue to be at a loss to understand why his employees act as they do until he has not only the information but the experience and background which will permit him to see the situation from the point of view of his employees.

JUDGE GARY AND WELFARE WORK

This is well illustrated by the conversation between Judge Gary and Lincoln Steffens, as reported in the latter's autobiography.[5] Steffens, you will recall, asked Judge Gary . . . "what he had done as a labor [leader], rather than as a company, leader. He [Gary] hesitated again before he said: 'Well, we have done a lot of welfare work.'"

"Welfare," I exclaimed. "You can boast of that? You must know what labor calls that—hellfare work."

"Yes, I know, but I don't understand why."

"I can tell you why," I said, and he seemed really eager to know.

"If you can explain that to me," he said, "you will render me a service, for I have never understood the bitter prejudice of labor against our appropriations for the improvement of the shop conditions."

"You don't understand why the wage workers, who want higher wages, are not pleased with cold showers, soap, and clean towels, neat dressing-rooms, lawns, and flowers?" He demurred at my list, but he

[5] Steffens, L., "The Autobiography of Lincoln Steffens," Harcourt, Brace and Co., 1931, pp. 693–694.

passed it with a laugh, and accepted my revised question: "You want me to tell you why, when your workers want whatever is coming to them in money for beer, they are not happy when you give it to them in white toweling?"

"Y-y-es," he frowned and smiled. "Yes."

"You have, I hear," I began, "a fine corner apartment in the Waldorf?" He nodded. "Well furnished, to your taste, and a lot of paintings on the walls—all of your choosing, all to your taste?" He nodded; he was a patron of art, and it was said that he did his own buying and collected pretty good things.

"Do you ever leave your apartment for a vacation?"

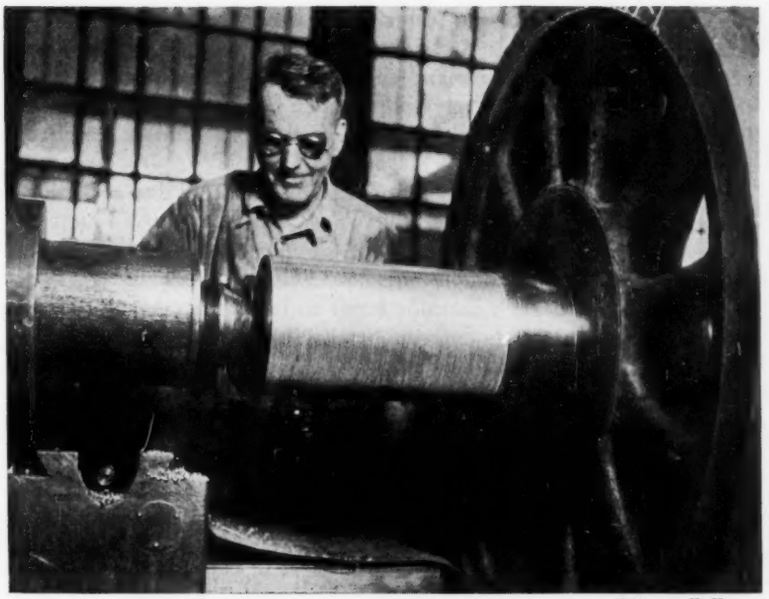
Yes, he did.

"Good," I said, "I'll make you a proposition. The next time you are going away for a period, let me know, leave me a sum of money, your own money, and give instructions in the hotel office to admit me to your quarters with permission to do whatever I choose to do."

Puzzled, interested, he screwed up his handsome face and asked, dubiously, "What will you do?"

"I will throw out that terrible furniture you like, and put in what I like, furniture to my taste. I'll take out your rugs and choose carpets in tone with the walls and the room generally. And the pictures —I haven't seen the paintings you have been collecting, but I am sure they are to your taste, not to mine; and I will replace them with good things, art, the sort of work I like. I'll do it all conscientiously, but I will completely alter and really improve the conditions in which you live, making them what I think they should be. And all with your money, the money you are wasting on your taste, which cannot be as good as mine. And—"

"Wait," he said, laughing. "I can't allow that, and even if I did, Mrs. Gary would not stand for it. But I get you." He sobered. "That's it, is it?"



Galloway, N. Y.

"FACTORS WHICH MAKE FOR THE HAPPINESS OF THE WORKERS ALSO RESULT IN THE DESIRED MORALE"

While the American workman is the most efficient in the world there is far more organized restriction of output by him both in open and closed shops than is generally realized. One of industry's greatest losses today is this loss due to restriction of output by workers. Even though it were conservatively estimated at but a small percentage of the total national wage and salary costs, it would still be a tremendous amount. This loss is due primarily to an attitude of hostility, resentment, or fear of exploitation on the part of the worker. In many cases this attitude may be justified; in other cases, not. At any rate, soldiering does not occur where the situation is such that the employee is motivated to do his best. All of our bonus and incentive systems are aimed at encouraging the employee, white collar or otherwise, to do his best. Most of them fail because they do not adequately take into account the employee's reaction to them and the way he feels toward the company. If he *feels* that the company is trying to exploit him, if he *believes* that the piece rate is likely to be cut—regardless of what the facts may be—he will restrict output, generally in an organized and effective manner.

There is increasingly less reason for this loss due to restriction of output. Management can to a considerable extent understand the forces responsible for labor's behavior if it desires to do so. Techniques have been developed for measuring accurately in a quantitative manner the attitude of labor toward management, toward working conditions, and other similar attitudes.[6] Furthermore, psychology has developed methods for determining the sources of these attitudes and has indeed an increasing body of knowledge which permits not only the intelligent interpretation of the causes of the various attitudes existing within labor, but points to the action to be pursued if we wish to change these attitudes in any desired manner. We have, then, methods for obtaining information about the underlying forces at play in the worker's life on the job and an increasing background of knowledge which permits us to interpret this information in such a manner that we can act so as to build morale and reduce soldiering and similar undesirable practises.

RECENT STUDIES OF LABOR'S ATTITUDE

Numerous recent studies support the statements just presented. Thus, for example, the fact that attitudes are not determined by intellect but by emotions is demonstrated by a study by Uhrbrock[7] of the attitudes of some 4500 employees of Procter and Gamble. He reports that there is very little relation between the employees' attitude toward the company and such items as the information they have about the company or their intelligence. On the other hand, abundant data in other studies are available to show that such emotional factors as the way they are treated in the employment interview and the manner of introduction to their

[6] See, for example, Thurstone, L. L., and Chave, E. J., "The Measurement of Attitude," University of Chicago Press, 1929, or Likert, R., "A Technique for the Measurement of Attitudes," Archives of Psychology, No. 140, 1932.

[7] Uhrbrock, R. S., "Measuring Attitudes of 4500 Factory Workers." Paper presented before the Chicago meeting of the American Psychological Association, 1933.

job show an appreciable relation to their attitude toward the company. A little sympathy and kindness in introducing a new and often nervous employee to a strange environment pays big dividends in increased loyalty and resulting production as well as in human happiness.

Another emotional factor which is exceedingly important in determining an employee's attitude toward his work is the treatment that he receives from his immediate superior. When this supervision is as it should be, the worker's attitude tends to be appreciably more favorable and his morale better than when the supervision is inefficient and poor. It is thus possible for management to use employee attitudes as a sensitive indicator of the extent to which foremen and those in similar positions are satisfactorily performing their supervisory functions.

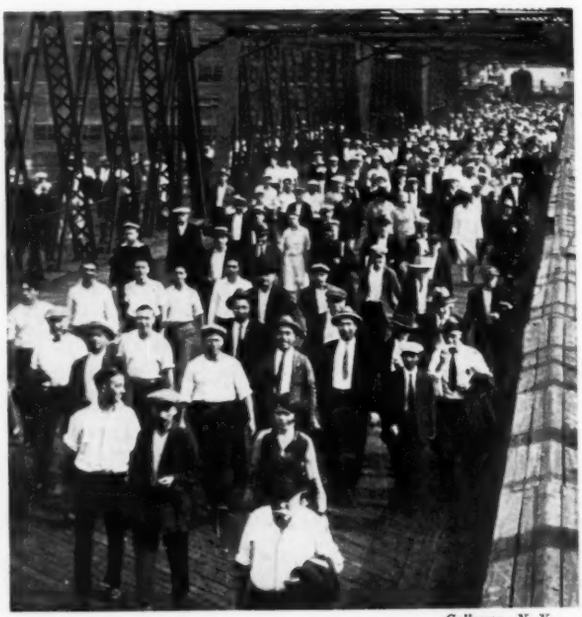
In many cases, as has been pointed out, the fundamental causes of unsatisfactory work or objectionable activity on the part of the workman exist in the industrial situation itself. In other cases, however, the real causes have their origin in situations outside of his working environment or may be due to an interaction between the two. A man's work is but a single phase of his total experience and the factors and forces determining his behavior outside of working hours do not cease to exercise their influence when he enters the factory gate. Why should we expect them to? Modern management must take into account not only the industrial life of the working man but all phases of his experience. Emotional disturbances aroused by a local political situation or a world series will manifest themselves in the man's work. A domestic problem which is causing an employee concern shows its presence in its effect upon production.

Furthermore, it is not only necessary to take into account all the forces and factors *now* at play in the life of the individual, but in addition it is necessary to recognize the importance of previous experience exercising its influence through the media of habits and emotional patterns. A man who has become a day-dreamer does not change his behavior patterns overnight. Such recent studies as that of Fisher and Hanna[8] and those of the Western Electric organization demonstrate the importance of these factors as determining the behavior of employees. The former particularly emphasize that much of our so-called vocational maladjustment, that is, failure of men on the job, is due not to causes existing within their present experience but to emotional maladjustment caused chiefly by earlier influences. This fact assumes considerable importance when we recognize that it is variously estimated that from 50 to 90 per cent of our total population is more or less emotionally maladjusted. If an employee, for example, is quite introverted and worries or broods about his lack of friends and social contacts and his inability to establish them, then no matter how capable he is nor how satisfactory the working environment, he will fail to produce what is expected of him. Many of our most brilliant and intelligent college students do mediocre or poor academic work because of emotional maladjustment of this or a similar kind.

Psychology, then, can contribute to industrial stability by providing management with the resources which will enable it to build the morale and cooperation necessary for happy and efficient production. Management must understand and utilize intelligently the various forces at play in the lives of their employees, whether these forces have their origin in the industrial situation, or outside of it, or are a function of previous experience. In a small organization the employer or manager himself, if he thoroughly understands these developments in psychology, can apply them to his situation. In a large organization, however, it is not enough that the executive officers thoroughly understand and use this material. An *adequate* and capable personnel department with a trained research division is indispensable.

From what has just been said it is obvious that many companies deceive themselves when they say they have a personnel department. They use the personnel department much as railroads use crossing gates; it is a convenient place to put some one with whom they do not know what else to do. Then, after calling this group of more or less cast-offs a personnel department, the management, after a sufficient period, really begin to think they have a personnel department. This kind of self-hypnosism is a rather common phenomenon.

A personnel organization to deserve the name must have persons who not only possess a considerable amount of interest in, and concern for, their fellow men but who are thoroughly trained in social and clinical psychology and related sciences.



Galloway, N. Y.

"FACTORS AND FORCES DETERMINING A MAN'S BEHAVIOR OUTSIDE OF WORKING HOURS ALSO EXCERCISE THEIR INFLUENCE WHEN HE ENTERS THE FACTORY"

[8] Fisher, V. E., and Hanna, J. V., "The Dissatisfied Worker," Macmillan, 1931.

A Formula for the SATURATION PRESSURE *of* STEAM *in the Range 0 to 374 C*[1]

By NATHAN S. OSBORNE[2] and CYRIL H. MEYERS[3]

IN A PREVIOUS report[4] the suggestion was offered that in the next revision of the International Skeleton Steam Table it might be advantageous to consider the adoption of a formula for the definitive relation between the pressure and temperature. It was emphasized that the standardization of this elementary property is an important preliminary step, necessary to the attainment of consistency and accord in comprehensive steam tables, since temperature and pressure are used as the fundamental coordinates.

Fortunately, the results of recent experimental work have sufficiently extended and fortified our knowledge of this property of steam to warrant a far more complete standardization than the present eight detached values in the skeleton table. The accord shown among the data of different experimenters using dissimilar experimental methods has reduced outstanding uncertainties so far that the vapor pressure between the freezing point and the critical region is now perhaps better known for water than for any other substance. Consequently, the available data have been studied with the object of seeking a definitive formula that might serve as a composite exhibit of the most trustworthy results.

The resulting formula here presented makes no claim to rationality or apparent simplicity, as these qualities have as yet eluded the inspiration of our group of workers. On the other hand, consideration has been given to the selection of a type which is adapted to numerical calculation of the pressure and its derivative and which is capable of truthfully representing the observed behavior of steam.

The path of approach to this problem has been the modification of a simple form of equation, long recognized as an approximation to experimental fact, by the addition of successive correction terms, each bringing a closer accord with the data. The numerous experimental steps in this process, many of which failed to meet the above requirements, are of no further interest, since the ultimate test made by comparing observed values with those calculated from these tentative formulas left no doubt of their relative fitness to represent both the individual values and the trend of the data.

The equation finally selected as the best according to this criterion has the form:

$$\log_{10} P = A + \frac{B}{T} + \frac{Cx}{T}(10^{Dx^2} - 1) + E(10^{Fy^{5/4}})$$

in which P = saturation pressure in international atmospheres
t = saturation temperature in degrees of the international temperature scale
$T = t + 273.16$ taken as temperature on the thermodynamic scale
$x = T^2 - K$
$y = 374.11 - t$ (374.11 taken as critical temperature)

and the parameters have the values

$A = +5.4266514$
$B = -2005.1$
$C = +1.3869(10)^{-4}$
$D = +1.1965(10)^{-11}$
$K = +293{,}700$
$E = -0.0044$
$F = -0.0057148$

The derivative dP/dt is given by the equation

$$\frac{dP}{dt} = P\left[-\frac{B + Cx(10^{Dx^2} - 1)}{T^2} + 2C\left\{10^{Dx^2}(1 + 2Dx^2 \log_e 10) - 1\right\} - \frac{5}{4}EFy^{1/4}\,10^{Fy^{5/4}} \log_e 10\right] \log_e 10$$

using the foregoing notation. A number of values of pres-

TABLE 1 SATURATION PRESSURE OF STEAM CALCULATED FROM FORMULA

t deg C	P atm	dP/dt atm/deg	t deg C	P atm	dP/dt atm/deg
0[a]	0.0060273	0.00043729	230	27.6130	0.50609
10	0.012101	0.00081023	240	33.0424	0.58094
20	0.023042	0.00142704	250	39.2557	0.66295
30	0.041831	0.0024015	260	46.3264	0.75246
40	0.072748	0.0038796	270	54.3313	0.84989
50	0.121698	0.0060412	280	63.3521	0.95570
60	0.196560	0.0091004	290	73.4752	1.07045
70	0.307520	0.0133048	300	84.7931	1.19479
80	0.467396	0.0189322	310	97.4057	1.32954
90	0.691923	0.0262878	320	111.422	1.47572
100	1.00000	0.035699	330	126.963	1.63483
110	1.41389	0.047509	340	144.168	1.80908
120	1.95938	0.062076	350	163.205	2.00197
130	2.66583	0.079765	360	184.294	2.22115
140	3.56630	0.100939	362	188.784	2.26932
150	4.69746	0.125966	364	193.372	2.31938
160	6.09964	0.155201	366	198.064	2.37166
170	7.81669	0.188998	368	202.861	2.42656
180	9.89596	0.227701	370	207.772	2.48495
190	12.3881	0.271637	371	210.272	2.51588
200	15.3472	0.321129	372	212.804	2.54858
210	18.8304	0.376508	373	215.370	2.58412
220	22.8978	0.438049	374	217.976	2.63069

[a] Water undercooled 0.01 deg from triple point.

NOTE: More extensive tables, including values in metric and English units, have been prepared. Copies may be secured by writing to C. B. LePage, A.S.M.E., 29 West 39th Street, New York, N. Y.—EDITOR.

[1] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce, Washington, D. C.

[2] Physicist, Bureau of Standards.

[3] Associate Physicist, Bureau of Standards.

[4] MECHANICAL ENGINEERING, vol. 55 (1933), pp. 116–117.

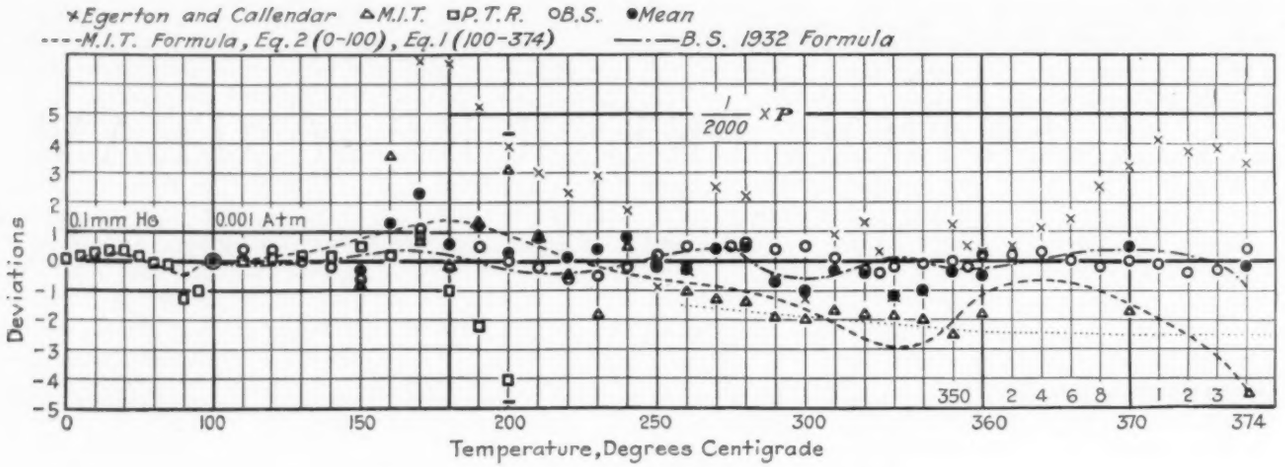


FIG. 1 COMPARISONS OF SATURATION PRESSURE OF STEAM

sure and of the derivative, computed from this formula, are given in Table 1.

As an aid in judging the accord of this expression for P with the experimental data and with other proposed formulas, a graph (Fig. 1) has been prepared. Deviations ($P_{obs} - P_{calc}$) from the values calculated by the above formula are plotted as ordinates against temperatures taken as abscissas. Since a uniform scale of coordinates over the entire range would exaggerate the relative importance of some of the deviations, the scale has been arbitrarily adjusted so as to facilitate their visual appraisal. Below 1 atm the unit of deviation has been taken as 0.1 mm Hg. Between 1 and 10 atm the unit is 0.001 atm. Above 10 atm the unit is one ten-thousandth of the pressure. Use of these units brings the scale of deviations to magnitudes comparable with the precision with which they can be measured. Appropriate changes of the scale of the abscissa avoid illusion where deviations in trend occur within a narrow range of temperature, as is the case near the critical region.

The data shown on the chart are taken from four sources, namely, the Physikalisch-Technische Reichsanstalt,[5] Egerton and Callendar,[6] the Bureau of Standards,[7] and the Research Laboratory of Physical Chemistry of the Massachusetts Institute of Technology.[8] The classic data of the P.T.R. between 0 and 100 C still stand alone, though published more than 20 years ago, and their values between 100 C and the critical temperature were not approached in precision by other experimenters for nearly two decades. Since they were obtained, there have been many advances in experimental technique, and while the more recent data have in part confirmed the earlier results in the high range, they have also in part indicated the need of slight modifications.

A complete review of the experimental technique will not be undertaken here, but it may be noted that the methods of the several groups differed in many important respects, and therefore the noteworthy accord shown in the results is all the more assuring.

The data compared have all been reduced to the basis of the present international temperature scale. The Egerton and Callendar data used are their smoothed values at even temperatures except at 170, 180, 190, and 200 C. In that range the values given by the series of measurements made in July and August, 1932, have been used after a preliminary smoothing and reduction to even temperatures, since those experimenters have regarded these later measurements as more trustworthy than their earlier ones. They note that this group of their data shows a systematic deviation from the results of other observers, and they recognize the greater limitation on the accuracy of their method at the lower pressures. This deviation, although amounting to about 0.006 atm, from the general trend of the mean, is, therefore, not serious. The effect of this departure is partly offset by the opposite though lesser deviation of the P.T.R. values at 190 and 200 C.

The differences in trend in the extreme upper range, among the Egerton and Callendar, the M.I.T., and the B.S. data, are noteworthy, but perhaps not surprising when it is recalled that the properties of fluids tend to become more indeterminate as the critical region is approached.

Where there are, at the same point, values from three or more laboratories, mean values have been plotted in order to consider the formula with reference to the entire mass of experimental data, and thus appraise its fitness. In computing these mean values, less weight has been given to a determination consisting of but a single observation than to others, but otherwise all independent values have been regarded as of equal importance. The task of assigning to each determination a more precise estimate of relative accuracy is too difficult and delicate, and, moreover, proves unnecessary for the present purpose. It may be seen by inspection that the accord of these mean values with the formula, taken as a reference datum, is well within a reasonable tolerance, giving consideration to the magnitude of the deviations. No significant anomalies are indicated, there being no systematic deviations of the mean values. The accord of the separate determinations is naturally less perfect, but not insomuch as to leave serious doubt of the fidelity of the formula as a tool for the adjustment and interpolation of the pressures, and for obtaining derivatives.

The derivatives, being removed one step further from the original data, are less accurate than the pressures, especially in

[5] Physikalisch-Technische Reichsanstalt. Warmetabellen, Friedr. Vieweg & Sohn, Braunschweig, 1919. Literature: K. Scheel and W. Heuse, *Ann. d. Phys.*, vol. 29 (1909), p. 723, and vol. 31 (1910), p. 715 (pressures at less than 50 C); L. Holborn and F. Henning, *ibid.*, vol. 26 (1908), p. 833 (pressures between 50 and 200 C); L. Holborn and A. Baumann, *ibid.*, vol. 31 (1910), p. 945 (pressures above 200 C); F. Henning, *ibid.*, vol. 22 (1907), p. 609 (comparison of older observations of saturation pressures).

[6] A. Egerton and G. S. Callendar, Phil. Trans. Roy. Soc., London, Series A, vol. 231, p. 147.

[7] Bureau of Standards. *Bureau of Standards Journal of Research*, vol. 10, Feb., 1933, p. 155.

[8] L. B. Smith, F. G. Keyes, and H. T. Gerry, Proc. Amer. Acad. Sci., vol. 69 (1934), p. 137.

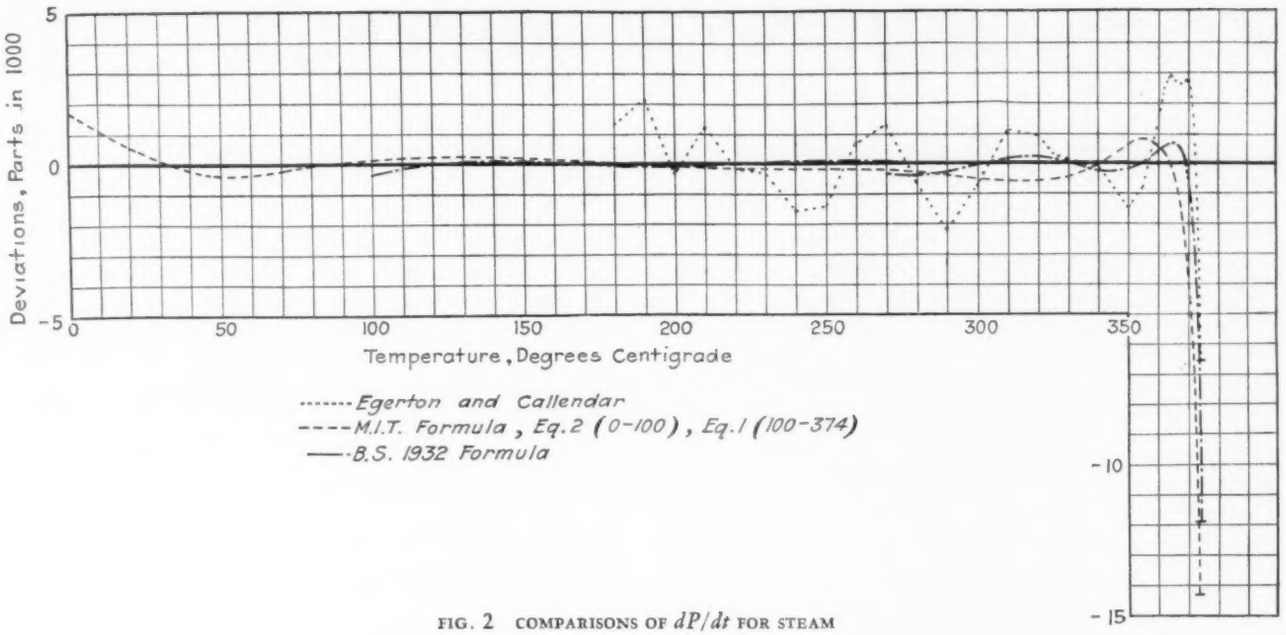


FIG. 2 COMPARISONS OF dP/dt FOR STEAM

certain regions. This may be appreciated by inspection of the graph of deviations of the derivative dP/dt plotted as percentages (Fig. 2), using values calculated from different interpretations of data.

The deviations between different evaluations of the derivative are seen to be greater in the regions of low and of high pressures than elsewhere. The uncertainty thus shown is not, however, of great importance in its effect on the general formulation of steam tables, although of interest from a scientific standpoint. The abrupt deviations shown above 360 C suggest that among the three observers, a large actual discord exists in the shape of the pressure line. This apparent discord is really artificial, due to the wide latitude possible in the individual interpretations of the data.

For example, of several formulas tested in the present study, one which was adjusted to the same mean data, using a least-square method of evaluating the constants, and giving careful consideration to relative weighting of the data, did not accurately follow the trend of the data in the upper range and gave even worse discrepancies in the derivatives. The equation was obviously of a form incapable of fitting the data, and was consigned to the waste basket.

As a further experiment it was found possible to assign to the M.I.T. data an adjustment with which the pressures agree within 1 in 5000 and for which even in the extreme upper range the derivatives agree with the present formula within 1 in 4000. Such an adjustment is indicated by the fine dotted line on the pressure deviation graph, Fig. 1. A similar adjusted interpretation could be made for the Egerton and Callendar data. This confirms the point that no serious discord actually exists among the data. Until more precise experimental evidence is available, which establishes more definitely the true course of the pressure curve on approach to the critical region, it seems proper to use a formula which represents a fair adjustment of the mean values of the data now available. The present formula meets this requirement even better than anticipated. The relative magnitudes of the terms in the formula are shown in the graph, Fig. 3.

The formula is evidently unsuited for routine use such as engineering calculations. No such formula is needed in conjunction with adequate steam tables. The primary purpose is to furnish a suitable medium for formulating this property of steam in compiling steam tables. When once the formula has been used to compute tables of pressures and derivatives, at intervals of temperature small enough to permit accurate interpolation, these tables may be converted to other systems of units, and amplified to any desired extent without further reference to the formula. All such tables will be mutually consistent. They are suitable for use as actual working tables, and in addition provide a convenient reference medium for intercomparison of numerical values expressed in different

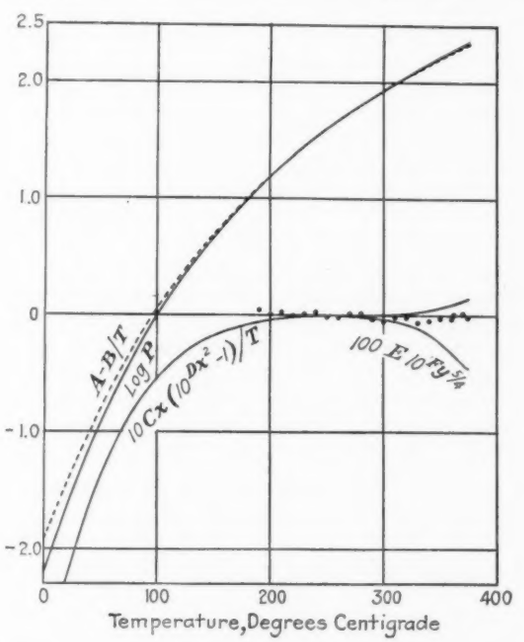


FIG. 3 CHART SHOWING RELATIVE SIZE OF TERMS IN VAPOR PRESSURE FORMULA

systems of units. The formula may still be used to express more concisely the equivalent of the tabulated values, as in establishing definitive relation for international agreement.

The JUNIOR MEMBER

A Study of His Relations to The American Society of Mechanical Engineers

ABOUT one-quarter of the membership of The American Society of Mechanical Engineers is in the junior grade, and the relations of this group to the rest of the Society have been studied to determine means by which the Junior may better serve the Society and himself, as well as some steps by which the Society may better assist the Junior in his professional life.

Necessary steps should be taken to secure appropriate contacts with new members and properly to introduce them into the life of the Society. New opportunities should be provided for professional training and development as an extension to more formal education, and as a preliminary to advancement in the Society. The local section should find a definite place in its activities for Juniors, and if necessary, should add to its program to make this provision. The burden of improving the relationship of the Juniors to the Society rests largely with the local sections in the means adopted for more rapidly absorbing the eligible Juniors into their normal meetings and committee work. Each individual Junior must prove on his own initiative that he is capable of such activity, and neither portion of any such program can be successful independent of the other part.

JUNIOR OBJECTIVES

The principal objectives of a young engineer in joining the Society may be stated very simply:

(1) Professional contact and acquaintance with other mechanical engineers.

(2) Technical news and data supplied through meetings, Society publications, and the Engineering Societies Library.

(3) Professional training and development.

(4) Prestige gained from membership in a professional society of recognized high position.

INTRODUCTORY CONTACT WITH THE SOCIETY

The act of joining the Society signifies that the new member is in a favorable and receptive mood, and this should be met by something more than a certificate of membership and a statement of dues payable. This opportunity should be seized to cement his favorable attitude and to give some guidance to his early contacts in the Society. It is suggested that the notice sent to all new members be altered to include the following items:

(1) Statement concerning the scope of activity of local-section meetings and the name and location of the nearest unit.

(2) Statement concerning the time and location of the Annual Meeting, a résumé of a typical program, and advantages of attendance.

(3) Professional Divisions:

a Name all the Divisions and outline the field covered by each

b Describe the A.S.M.E. Transactions, the method of securing copies regularly, and the cost of additional copies

c Give means of locating places where Transactions are available.

(4) A brief summary of the purpose and work of the Technical Committees.

(5) Describe briefly the Society publications other than Transactions:

a MECHANICAL ENGINEERING

b Technical papers presented at meetings

c *Mechanical Catalog*

d Test codes and other publications.

(6) Describe briefly the purpose and services of the Engineering Societies Library with special reference to its use by non-residents of New York City.

(7) Employment service:

a Directions for enrolment

b Privileges and services

c Cost.

(8) A statement directing attention in appropriate fashion to the A.S.M.E. "Code of Ethics for Engineers."

In addition to this information, copies of the Constitution, By-Laws, and Rules, and a statement of the current policies of the Society management should be included if circumstances permit.

Some members of the local section in which the new Junior is located should either accompany the new man to a meeting, making appropriate introductions, or, if that is impossible, a personal letter of welcome should be mailed to him by some officer of the section. This individual action will materially assist in permanently fixing a favorable attitude toward the older members.

An introductory contact somewhat as outlined would impress on the new Junior that the Society has some interest in him beyond the necessary financial transaction.

PROFESSIONAL DEVELOPMENT AND TRAINING

Important objects of the Society are "to promote the art and science of mechanical engineering, and to foster engineering education." It may reasonably be assumed that the junior group has acquired most of the necessary fundamental training in the "science" of engineering and is engaged principally in learning the "art" of engineering, the skilful application of systematized knowledge or science. To Juniors who actively pursue this objective, the Society can and should be of material assistance in furnishing counsel and guidance. Papers presented before the Society and subsequently printed in its publications are, in most cases, prepared by members mature in judgment, skill, and experience, and in general, represent

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A report by the Committee on the Relations of the Junior Member to the Society, presented at the Annual Meeting, New York, N. Y., Dec. 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The personnel of the committee is as follows:

J. H. ADKISON, Tulsa, Okla., S. F. DUNCAN, Los Angeles, Calif., W. J. HARGEST, Brooklyn, N. Y., R. KUTZLEB, JR., Brooklyn, N. Y., C. W. MESSERSMITH, Lafayette, Ind., J. C. S. MOORE, Chatham, Ontario, Can., D. B. WESTROM, Bloomfield, N. J., and R. F. GAGG, Paterson, N. J., *Chairman*.

the advanced technical views of the authors. These papers are, of course, both necessary to and desired by the Junior for the advancement of his technical viewpoint. However, the suggestion is put forward that senior members of the Society could well demonstrate consideration for the interests of the Junior by examining critically their early experience and sifting from the past some lessons to be passed on to present Juniors.

The early years of his professional life constitute a critical period for every engineer, and his efforts toward surmounting the educational deficiencies which experience always uncovers may have a profound effect on his later development. Because of the individual nature of the problems involved, it is evident that a satisfactory solution can only be attained through basic self-analysis of each case and the formulation of an orderly program for improvement adjusted to personal requirements. The Society can offer assistance in this stage by furnishing an orderly outline or form for a specific determination and statement of the individual's analysis of his own situation. The most important assistance could be offered, however, by appointing in each locality a small group of men chosen for their tact and good judgment to act as counselors in the solution of any individual Junior's own particular problem. The counselor could assist in the selection of courses for study or in choosing a list of books to be read, supplementing but not supplanting individual initiative. The procedure would involve a relation in some ways analogous to that of the master craftsman and apprentice of the medieval guild, and may prove to be distinctly worthy of professional recognition.

The means suggested for the transfer of experience and guidance of professional development must be supplemented by a wide increase in personal contacts between the Juniors and other members. This is in accordance with the object of the Society "to promote the intercourse of engineers among themselves and with allied technologists" as expressed in the Constitution. The reticence of the engineer in actively participating in social and technical activities appears to have become an accepted paradox. A similar situation existing in his daily work would at once be subject to technological attack. In the solution of this problem, the Juniors may lend material assistance, for they are not yet enmeshed in the demands of the profession or submerged in any of its specialized channels, and therefore should be able to offer a fresh attack on this traditional stigma of engineers The free communion of kindred minds is essential to the solution of this social problem, and it should be noted that this injunction of the Constitution of the Society is as binding in its demand for observance as are its other clauses.

A JUNIOR FORUM SUGGESTED

It is certain that the senior members desire the complete participation of Juniors in all the normal activities of the Society (so far as their capabilities have been demonstrated) rather than an unnecessary extension of what might well be called their period of probation. However, this does not necessarily conflict with the establishment of a junior forum for discussion and action on problems peculiar to the young engineer, and both kinds of activity may exist side by side.

A majority of the junior group is composed of young men who have graduated with a bachelor's degree granted after four years of study in a college of engineering. Most of them have had little, if any, technical experience in industry, and for several years bear a distinct consciousness of this deficiency. They soon realize that in spite of the best efforts of their professors, they failed to learn in college many of the technicalities needed in their work, and especially, that they failed to learn to write and to speak before an audience with clarity and facility. They have had, perhaps, a little experience in appearing before meetings of students but not enough to make it easy to overcome a distinct feeling of inferiority in appearing before a body such as a regular Society meeting. This handicap may eventually be overcome by providing a junior forum primarily concerned with the interests and problems of the younger men. This body should be recognized and assisted by the local section, but the Juniors should be reasonably free from any restraining paternalism. At least in the early stages of such a movement, the individual preferences of each group should be allowed full leeway to develop the best possible type of organization.

Since the fall of 1931, a junior division of the Los Angeles Section has been meeting for one hour in advance of the regular monthly meeting of the section. Membership in the division is limited to Juniors and student members and attendance at the meeting is not urged on other members. The division is governed by an executive committee composed of three Juniors and two student members, each man holding office for one year only in order to spread the experience among a large group. Papers presented at the division's meetings have been largely concerned with matters of general interest to engineers, rather than narrower technical subjects. This year some of the junior members are to prepare papers for the regular section meetings.

A similar group has been meeting in New York for the past year under the guidance of a governing committee composed of four members of the junior group and one member from the executive committee of the Metropolitan Section. Meetings are held semi-monthly with programs consisting of papers prepared by Juniors or by older members on invitation, round-table discussion with elder leaders in engineering, and short inspection trips. The meetings and programs are arranged with the object of improving acquaintances and providing a free discussion of topics considered, the latter being selected for their widespread current interest.

In these meetings the Junior feels that he is appearing before his peers and can freely express his opinions without fear of incurring the displeasure of his seniors in age or experience. Possibly some of the technical papers produced will be of such excellence that their presentation before regular section meetings may be desired.

This sort of activity provides new acquaintances and a place in the Society for the large group of Juniors who are either unwilling or unprepared actively to participate in the established routine of Society meetings and committee work. The groups active in Los Angeles and New York are good examples of what may be accomplished.

ACTIVE SERVICE FOR MORE MATURE JUNIORS

Passing now to a second group of Juniors who are anxious and better prepared to be absorbed into the senior organization, it is believed that the best way to fit them for later leadership is to assign to them yeoman service in all the normal activities of the Society. Until an engineer learns to work for his professional society he has but little real appreciation of its potential worth and gets from it comparatively little, if any, benefit. Perhaps many of the efforts contributed by Juniors will be of little value to the elder members, or to the Society as a whole, but to the Junior they are of utmost importance, for this is the beginning of his life in his professional society, something akin to a first job in industry, a most critical period.

This class of Juniors should frequently participate in the

regular meetings of the Society. They are often directly engaged in research and development work, and are in a peculiarly favorable position to prepare papers of wide current interest. In this way they can perform a real service to the profession. It is suggested that a much wider use of the practise of collaboration between an elder member and a Junior in the writing of technical papers might be wholly beneficial to the authors and to the papers produced. The plan has much to recommend it in securing a wider participation of Juniors, and it also makes the task of preparation much easier for the senior author.

JUNIOR AWARDS

The present award bestowed annually for the best paper contributed by a Junior, consisting of an appropriate certificate and fifty dollars, offers an excellent stimulation to Junior effort. However, it is believed that the effect might be improved if one or two additional certificates of honorable mention were also awarded, providing that the material submitted warranted such action. The position of the Society does not allow the graceful granting of a prize of less amount than that mentioned, and its financial situation does not permit any material increase in outlay for this award. It is believed that the suggested change in procedure might broaden the competition without seriously detracting from the honor bestowed on the recipients.

PARTICIPATION IN MEETINGS

Very few young men surrounded by a group of their elders will volunteer their services or opinions, and, therefore, it seems necessary to draw them into participation through a process of individual selection. In the preparation of the winter program for a series of section meetings it is suggested that one or two sessions be arranged to present a Junior and a senior member, in collaboration or separately, so that the younger men will be impressed with the fact that their position parallels and supplements that of their elders. Wider use of the "panel" method of topical discussion might be a way of accomplishing the desired object.

The presiding officer at every meeting should be charged to see that at least one Junior speaks voluntarily or is called upon when open discussion is in order. Even though the initial response may be disappointing, this practise will assist in securing a gradual improvement in the quality as well as in the frequency of Junior participation.

The benefits of personal association and acquaintanceship with members of the Society only come to the Junior as the reward of frequent attendance at meetings and careful attention devoted to tasks assigned. It seems futile to ask that the older members do much more than to assist and recognize merit where it is encountered in a Junior as they would in the case of any other member. It is obvious that the Junior should make the best possible use of the associations available in all of the Society meetings, and it is clearly his own responsibility to take advantage of the opportunities provided.

OPPORTUNITIES IN TECHNICAL COMMITTEES

The important technical-committee work of the Society must necessarily be guided and largely administered by the more experienced members, but it is believed that there is also a proper place for the Juniors in this work. Many regular committee members find it impossible to attend all of the meetings of their committees and it is suggested that a carefully selected Junior might well act as alternate or reporter in the absence of the member. In cases where the member must travel a long way to the regular meeting place, a Junior alternate might be selected from the immediate vicinity of the meeting place. If this practise were widely adopted, the absent committee member would receive a special report on action taken in his absence, and a rather large number of new men would be introduced to this important Society activity. It is quite possible that these Junior alternates could also be utilized to good advantage from the committees' viewpoint in the collection of data, or similar duties. Every alert Junior would be delighted at having such an opportunity for service.

PARTICIPATION IN ADMINISTRATIVE COMMITTEE WORK IS SUGGESTED

The Meetings and Program Committee has been conducting an experiment in junior participation for the past two years which has provided interesting and instructive training for one Junior. This man was invited to attend and generously to participate in all of its meetings as a sort of unofficial representative of the viewpoint of a younger member of the Society. The work on the committee has not been noticeably hindered, and the fortunate Junior has benefited greatly. It is suggested that an extension of this practise into most of the administrative committees, including those of the local sections, would serve a most useful purpose in training the younger men. Since only a comparatively small number of Juniors may be so favored, only those who have shown special ability, either in technical committee work or otherwise, should be selected for this service.

The administrative committees of the local sections provide excellent opportunities for the Junior to render a real service to the Society in assisting with the host of details which must have careful attention if the section meeting is to be a success. The entire executive committee of one local section is made up of Juniors, and less extensive but similar experiments have been tried elsewhere with varying degrees of success. The practise provides an admirable opportunity for developing early in their professional life the leaders who may pilot the Society in later years. This is obviously essential if it is to prosper in the next generation.

The Junior members must make the best possible use of the numerous associations and privileges already available, and it is clearly their own responsibility to take advantage of these opportunities. There is no substitute for individual initiative. However, it is believed that the Society can and should act upon some of the specific steps suggested in this report as a means of more rapid and complete assimilation of the junior group. Joint action is required from both Juniors and the elder engineers if the objective desired by both is to be achieved.

IN THE First Annual Report of the E.C.P.D., the Committee on Professional Training, R. I. Rees, chairman, gave consideration to the problem of the junior member of engineering societies. The committee commented on the following: (1) A need of a survey of junior members to determine the number, names, location, educational, and occupational background of such members. (2) A personal-analysis blank that the committee had developed. (3) A survey of educational facilities in areas of concentration of junior membership. (4) A study of basic objectives for independent reading of junior members, and a reading list. (5) The need for a comprehensive presentation of a program of education to meet requirements sent by the Committee on Professional Recognition. (6) Conferences it had held to develop procedures for enlisting the interest of senior engineers.

INDUSTRIAL EDUCATION *in the* CENTRAL STATES

By ROBERT H. SPAHR[1]

WHATEVER CHANGES, procedures, policies, or plans of control Fate may hold in store for American business and industry, one fact stays put; human beings must and will be required always.

New processes may be substituted for the old, a material may replace another, a product may become obsolete, new products may be devised, yet man remains as a physical unit. He is indispensable in connection with the world's work. Conditions, as well as society, however, may demand that he be trained mentally and physically better than before; he may need to become more adaptable than heretofore, able to do effectively more than one thing.

Business and industry in the past, present, and future have varieties of jobs calling for persons with widely diversified training. The emphasis of greatest need may shift from one group or function to another, from time to time, and from place to place; indeed, certain positions may be expected to become extinct, while others may come into being in relatively brief periods of time. These shifts necessitate many human adjustments, many persons requiring original training, others requiring retraining.

Naturally, the ideal of effectiveness, for both employer and employee, would be that the employee have exactly the right education and training for his job. Since this is obviously impractical, suffice it to say that each position in business and industry should be filled by a person having at least the minimum education and training required for the most effective and efficient performance. Relatively little is yet known or available for general use as to the education or training necessary for jobs or even for fields of employment. No methods, procedures, or formulas have yet been devised to place men universally in positions with even fair assurance that the selections will be right, although encouraging beginnings are being made.

Were even the minimum industrial requirements for trained men to be met, which many samplings indicate they are not, we might have little cause for immediate concern. In the studies of the S.P.E.E. the data indicated that three times as many technical-institute men as college men could be used effectively, and that approximately fifteen times the number of college men needed should be trained in the more or less vocational or trade courses. Otherwise, under normal conditions, both the employers and employees pay the costs through inefficiencies, frequently due to the absence of the proper amounts and kinds of training needed for their jobs. While the amount of costs chargeable to these particular deficiencies is intangible, it is apparently real and large, for in no instance are the employers' estimated requirements for trained men nearly supplied; in one case, their studied estimates call for fifty times as many annually as are now available from our present training sources. Naturally, this means that many positions in business and industry are yet filled by untrained persons. Also, it must be recognized that these estimates, for more or less normal times, call for perfect distribution of the men trained in the various fields.

Inasmuch as it was impracticable to conduct a comprehensive inventory of what remains from all of the training activities in the central states after the past four years of wreckage, a carefully planned sampling process has been used for the purpose of this discussion. The data in Table 1 are based on the activities of nine companies, known to have had educational programs in 1929, and representing brass, iron and steel, foundry,

TABLE 1 GROUPS OF TRAINING ACTIVITIES IN 9 COMPANIES—1929–1933, INCLUSIVE

Groups of Training Activities	No. of companies participating	Average no. trained per year per company
(1) Trade Apprenticeship Training		
Machinist	8	24.0
Foundry	2	16.6
Pattern making	5	3.2
Electrician	5	5.3
Pipe fitting	2	1.0
Carpentry	2	0.5
Tool making	1	0.8
Miscellaneous	3	15.9
(2) Executive or Foreman Training		
Prospective foremen	2	29.4
Present foremen	6	54.6
Major executives	1	135.0
(3) Job or Shop Training		
Organized conferences	2	127.4
(4) Sales Training		
Merchandising or store training	1	449.0
Traveling salesmen	3	14.4
District representatives	1	1.6
Sales managers	3	10.5
(5) Technical or Operating Training		
Metallurgy	1	23.6
Drafting	3	19.4
Cost control	1	2.0
Time and motion study	2	5.2
Company products and processes	1	8.4
(6) Service Training		
Service men	4	945.4
(7) College-Graduate Training		
Engineering and design	2	3.6
Technical sales	3	5.9
Production	2	5.7
Service	1	4.0
Supervisory—factory	2	17.8
General—company background	1	35.8

[1] Director, Instruction and Curriculum Development, General Motors Institute of Technology, Flint, Mich. Formerly Director, Employer-Employee Relations Service, Chamber of Commerce of the United States. Mem. A.S.M.E.

Contributed by the Committee on Education and Training for the Industries and presented at the Semi-Annual Meeting, Chicago, Ill., June 25 to July 1, 1933, of The American Society of Mechanical Engineers.

light machine tools, heavy machine tools, electrical equipment, railroads, public utilities, and soap. In addition, supplementary data and analyses are based upon representative trade-association activities.

Table 2 shows a summary of the training activities in the nine companies by years, by types of training, and the number of companies participating in each activity. The nine companies represent between 55,000 and 65,000 employees; thus many deductions may be made from these figures which time and space will not permit here.

TABLE 2 SUMMARY OF TRAINING ACTIVITIES IN 9 COMPANIES BY YEARS

Type of Training	No. of companies participating sometime during period	Number of persons in training 1929	1930	1931	1932	1933
Trade apprenticeship	9	498	448	276	195	179
Executive or foreman	6	774	599	375	402	456
Job or shop	2	200	296	139	331	308
Sales	4	687	554	477	495	412
Technical or operating	4	156	197	98	34	28
Service	4	4060	4058	3557	3504	3728
College graduate	5	240	171	112	15	21
Total		6615	6323	5034	4976	5132
Total, excluding "service"		2555	2265	1477	1472	1404

TRADE APPRENTICESHIP

All of the nine companies conducted trade apprenticeship training during at least two of the past five years; one company discontinued this training in 1931, and another in 1932.

Apprenticeship courses surviving to date are machinist, pattern making, foundry, electrical operator, electrician, and boiler making; those courses which have been discontinued are tool making, carpentry, pipe fitting, masonry, and blacksmithing. The classifications of machinist, foundry, electrician, and electrical operator account for 89 per cent of all the apprentices trained in these nine companies during the depression period, and machinist apprenticeship alone accounts for 60 per cent of the total number.

It is interesting, as well as instructive, to observe that tool-making apprentices, trained in considerable numbers in earlier years, appeared as only three-tenths of one per cent of the total apprentices trained in the nine companies during the period under consideration, and further that the training of tool-making apprentices was discontinued entirely in 1932; other phases of apprenticeship training are holding their own through the years; still other phases have been inaugurated to prepare for new or changed industrial processes. An example of the latter is welding, which, as a new process of joining pipe, has necessitated the retraining of large numbers of men who are now steam fitters as well as the training of apprentices in this process; the training of supervisors, engineers, estimators, and salesmen in new scientific developments such as air conditioning is another example.

At least one of the nine companies does not concur with the majority that trade apprenticeship continues to be essential in business and industry. This representative believes that job or shop training under good supervision should supplant apprenticeship training.

One large company thus sums up its apprenticeship situation: "Just so long as the general tendency is toward specialization or development of machine operators, our company will have to train apprentices either formally or informally."

EXECUTIVE OR FOREMAN TRAINING

There can be no mistaking the value which practically all of these companies place upon executive or foreman training. Six of the nine companies conducted executive or foreman training since 1929, one discontinuing this training in 1931 and another in 1932. Even though this activity dropped to its lowest point in 1931, and the number in 1933 is smaller than in 1929, the numbers are impressive for a depression period.

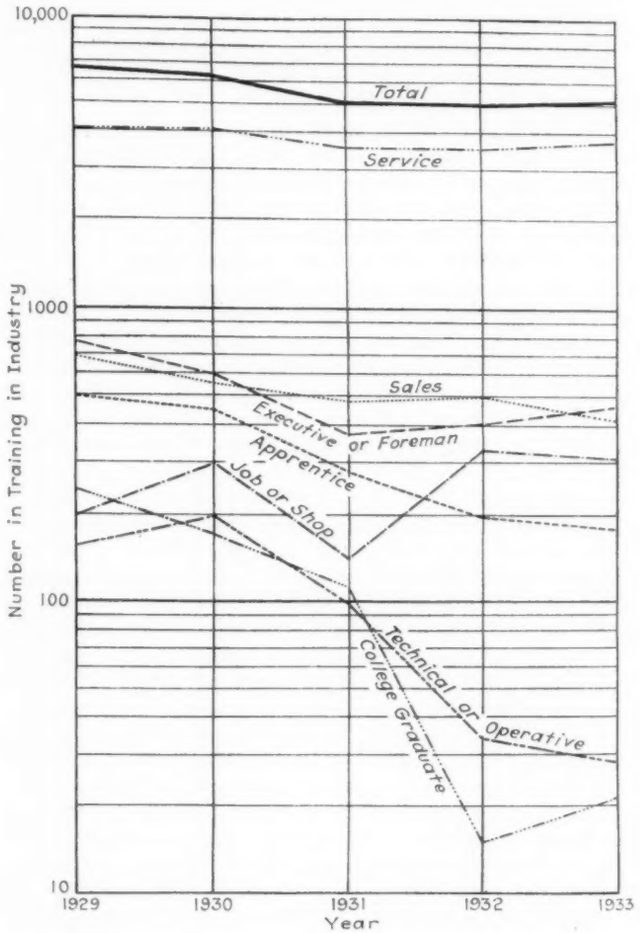


FIG. 1 SUMMARY OF TRAINING ACTIVITIES IN 9 COMPANIES—INDICATING TRENDS

(Representing such industries as brass, iron and steel, foundry, light machine tools, heavy machine tools, electrical equipment, railroads, public utilities, and soap.)

A significant observation is that these companies that temporarily discontinued executive or foreman training expect to carry on the work again, and others anticipate enlarging their programs in this field.

The objectives of executive or foreman training for one company are set forth concisely as follows:

> In such an industry as ours, a choice must be made between two policies: First, the employment of technical graduates, and the training of them for executive practise; or, second, following a policy of promotion from within, promoting those of known or suspected executive ability, then giving them requisite technical training. We follow the second method principally, depending upon the first for a limited number who give promise of advancing to higher positions, and to sales positions.

JOB OR SHOP TRAINING

The curve, Fig. 1, representing job or shop training is interesting, but hardly conclusive since it represents activities in only two of the nine companies. However, it does indicate certain possibilities for "mass" production in the field of training.

In connection with persons trained in this field, the general impression is that the public vocational and trade schools in the larger industrial centers are performing an excellent service, while on the other hand, as one company, with experience, puts it, "In smaller communities, the so-called manual training or vocational training is of no value."

The schools of Cleveland, Ohio, and Milwaukee, Wis., were cited as being particularly effective.

SALES AND SERVICE TRAINING

Four of the nine companies conducted sales training. In 1929 there were 107 traveling salesmen in training in the four companies, and in 1933 only two. This accounts for the considerable drop in the sales curve, Fig. 1; for, with traveling salesmen omitted, the activity would be shown as nearly holding its own over the five-year period. A significant fact is that the training of sales managers increased two and one-half times in five years.

The number in service training is large, reflecting the activities of a large public-utility company; the curve representing service training has been more consistent throughout the depression than has been that of any other single group of training activities.

Competitive conditions, technical improvements, and scientific progress do not appear to be lessening the need for training on the whole, but rather they appear to be enlarging the field of training activities in the direction of merchandising and sales-promotion programs. In this direction, one company comments:

> Improvement in morale through this understanding and ability to deal more effectively with the customers (which brings satisfactory customer relations) are two results which we have observed by the introduction of this type of training program in addition to the training program covering the personal-service phases of public-contact work.

A chain-store organization, operating in the central states but not included in this survey, was so well pleased with the results of training in its merchandising organization that it has expanded this activity even though it has been obliged to watch expenses very closely.

During the present year, experiments were conducted in the training of several trade groups, including milk salesmen, laundry salesmen, department-store sales people, and bakery salesmen, with the most gratifying results. A comparison of the sales records of the bakery salesmen in the training program with the sales records of an equal number not in the training program reveals interesting and significant data. The sales records of both groups were analyzed at the time training began and again at the conclusion of the training program, seven weeks later. At the end of the seventh week, the group not in the training program showed a decrease of one per cent in sales, while the equal number in the training program showed an increase of 6.2 per cent, or a spread of 7.2 per cent in the performance of the two groups.

While training for the merchandising and sales functions in business and industry, including department stores, chain stores, laundries, dairies, bakeries, and other similar business units is perhaps one of the newer fields to be developed on a sound and effective basis, it offers unbounded possibilities. We may logically expect further developments in this particular direction.

TECHNICAL OR OPERATING TRAINING

The trend of technical and operating training activity seems to be away from the technical subjects such as drafting and metallurgical instruction and toward subjects in the operating field such as time study, motion study, cost control, and company products and processes; these trends are particularly emphasized in the past two years.

COLLEGE-GRADUATE TRAINING IN INDUSTRY

Six of the nine companies trained college graduates during the period under discussion; three companies have eliminated this activity, at least for 1933. It is noted that the numbers were not large, and that the slope of the curve, Fig. 1, indicates the most drastic reduction of all the groups. The training of college graduates for the service functions in industry was the only division of college men that did not decrease in number over the five years, although college men being trained for factory supervisory positions made a fair showing in maintaining numbers throughout this period.

The question was asked if the company employs college graduates for training, and if so whether there is any preference in the type of education and training to be had by these graduates, at the same time suggesting the following courses from which to express preference: General academic or arts, general science, business administration, engineering—usual four-year course, and engineering—cooperative five-year course. The preference was expressed in the following order: (1) Engineering—usual four-year course, (2) engineering—cooperative five-year course, (3) business administration, (4) general science, (5) general academic or arts. It is interesting and instructive to observe that "engineering—usual four-year course" received more first preferences than all of the others combined.

DATA FROM TRADE ASSOCIATIONS

The National Metal Trades Association made available for comparison its latest figures on trade apprenticeship, as of January 1, 1932, covering member companies in the central states (Table 3). Some of the nine companies, previously tabulated in this paper, undoubtedly are included in the N.M.T.A. survey.

The data from the N.M.T.A. cover only two years of the five, 1929 to 1933, inclusive, being considered, yet when these are plotted on the chart, Fig. 1, the slopes of this curve parallel quite closely the slopes of the apprenticeship curve representing the nine companies. This comparison serves as a check and assists in indicating what remains in trade-apprenticeship training in 1933.

Other information, not altogether comparable yet indicative of the present training status in industry, was furnished by the Heating and Piping Contractors National Association. Numbers have been reduced in this association's organized educational and training program in trade apprenticeship, in the upgrading of journeyman, and in foreman training; yet, apprenticeship and journeyman training programs are still in operation in the central states, in Cincinnati, and in Chicago. Welding-training programs are also being given in some of the smaller cities in the central states. A new development within the past year has been training in air conditioning, and three groups in the central states are now studying this subject, in Louisville, St. Louis, and Milwaukee.

Another educational and training development in the central states, tremendously significant for industry and trade associa-

TABLE 3 TRADE APPRENTICES REPORTED BY THE NATIONAL METAL TRADES ASSOCIATION

City or Center	No. of Apprentices 1930	1931	Per cent of 1930	No. of Plants 1930	1931
Central Illinois (Peoria)	3	0	0	2	0
Chicago, Ill.	279	240	86	37	54
Cincinnati, Ohio	326	150	46	29	19
Cleveland, Ohio	119	68	57	23	15
Columbus, Ohio	65	44	68	15	11
Detroit, Mich.	141	35	25	11	3
Grand Rapids, Mich.	24	9	38	9	4
Indianapolis, Ind.	60	33	55	7	10
Jackson, Mich.	14	13	93	4	3
Milwaukee, Wis.	952	705	74	27	27
Muskegon, Mich.	20	4	20	5	2
St. Louis, Mo.	109	66	61	25	20
Toledo, Ohio	91	62	68	8	7
Tri-City (Moline, Ill.)	65	21	32	8	4
Totals	2268	1450		210	179
By States					
Illinois	347	261	75	47	58
Indiana	60	33	55	7	10
Michigan	199	61	31	29	12
Missouri	109	66	61	25	20
Ohio	601	324	54	75	52
Wisconsin	952	705	74	27	27

tions, is the work of the American Institute of Laundering, at Joliet, Ill. The Vocational Training School forms a part of the institute. It offers to men and women a one-year course of intensive training in the five major divisions of laundry operation and management.

Each of the five divisions occupies an eight-week period in the training program, and the complete year's course is so arranged that the student may take one or all of the periods, as he desires. These divisions are: Power-plant engineering, production and plant design, textiles and washroom practise, accounting and office administration, and sales, service, and advertising.

The purpose of these courses is to train foremen, superintendents, and managers in the art, science, and practise of laundering. The work of the training school is coordinated with a number of other departments and activities of the institute, including research laboratories, engineering, cost accounting, merchandising, and public relations (Table 4).

TABLE 4 NUMBER OF STUDENTS ATTENDING THE AMERICAN INSTITUTE OF LAUNDERING SINCE ITS OPENING IN 1930

Eight-Week Courses	Enrolments during the years 1930	1931	1932	1933
Textiles and washroom practise	20	42	29	32
Accounting and office administration	12	28	21	21
Sales, service, and advertising	13	25	19	18
Power-plant engineering	23	21	23	[a]
Productions and plant design	36	27	30	[b]
Totals	104	143	122	71[c]

[a] Sept. 6 to Oct. 28.
[b] Oct. 31 to Dec. 22.
[c] Incomplete.

GENERAL OBSERVATIONS AND SUMMARY

Much has been said concerning the elimination of training in business and industry during the past five years—some discontinued for economic reasons, others because of the apparent abundant supply of trained persons now unemployed. Many have suspected exaggeration in these statements because of the wider publicity given to discontinuances than to the simple continuances of educational and training activities. The foregoing samplings from individual companies in different sections of the country, from different industries, and from different-sized establishments, as well as from samplings taken from the trade-association field, show that there have been reductions, in some instances drastic ones. However, on the whole it may be surprising to many to observe the large amount of training remaining in industry in 1933, after four years of acute business depression.

Much of the education and training in business and industry has weathered the storm of depression. This is surprising, even significant, in the light of what happened in the early twenties. At least two causes contribute to this effect: Sounder and more effective programs of training evolved through experience, and a growing recognition of the need for and the value of the right kind of training programs.

Phases of education and training in industry emphasized by the nine companies as being important at this time included the necessity of developing skill in handling human problems, the importance of continuity in industrial training programs, the desirability of more attention to background training, aptitudes, and apparent tendencies for purposes of better selection and placement, more complete analyses of jobs for purposes of immediate intensive training, more effective observation for purposes of checking judgment of placement, promotion, and separation, and finally a statement by the president of one of the companies that, "There is no question but what the most essential thing that any young person needs is an education. Business and industry can be most helpful in backing to the fullest extent our institutions of learning."

As history, it is interesting to note graphically in Fig. 1 that 1931 seems to have been the turning point in the field of education and training in business and industry. It is interesting, significant, even prophetic, to note the actions of the "total" curve showing 77.6 per cent as many persons in training in industry in 1933 as there were in training in 1929.

Relatively few functions or activities in business and industry enjoy absolute continuity; they are dependent on the ups and downs of business conditions. The "hand-to-mouth" policy in management, contrasted with studied and planned policies, has, perhaps, offered the path of least resistance. Many who have followed these unplanned policies have had no alternative. While admittedly possessing personality and perhaps leadership qualities to drive forward in a vivid and inspiring way, they have lacked knowledge of basic technical phases, of modern economic principles, and of the social structure into which they are supposed to fit as a practical working composite. The same men frequently forget or ignore the fundamental fact that many activities in business and industry, by virtue of their characteristics, cannot be efficiently operated by an "off again, on again, gone again" policy. Efficient training in and for industry offer no exception.

Perhaps a comprehensive program in education and training should not be carried on by a company itself unless it may be demonstrated that it is in a position to produce more effective training results than may be obtained through other available sources. If industry finds it advantageous to carry on education and training within its organization, then is it more economical to discontinue such activities during business depressions, as is sometimes done, and rebuild them each time with the accompanying losses or to continue at least a skeleton organization, as is often done with many of the other activities in an organization? It must be kept in mind always that many educational and training activities are long-process operations which to be really effective should be planned and budgeted years ahead. If we assume that changed conditions are affect-

ing the industrial requirements for trained men, what are the trends and questions which appear vitally important at this time?

Changed or changing conditions may be expected to affect training in business and industry. Certain of these changes, perhaps, already are indicating directions or the increased necessity for better and sounder programs of training in industry; others are yet too vague to indicate trends. For example, if compulsory unemployment insurance becomes widely formulated into laws, there perhaps will be a vast increase in the training activities within an organization, involving large working forces instead of specialized groups, so that these employees may be transferred from one job to another to avoid, as far as possible, laying them off and making them, as its employees, eligible for unemployment insurance.

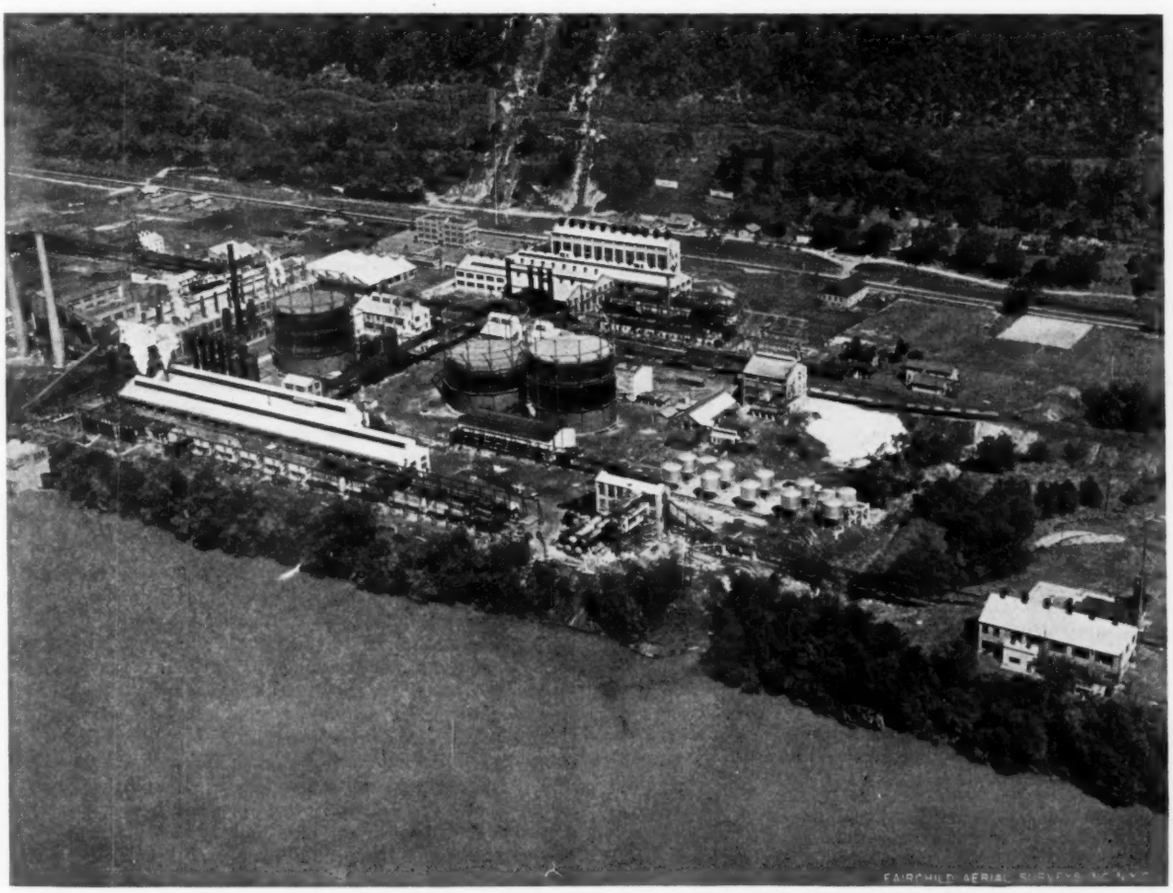
The shorter work time per week should be anticipated in connection with training within industry. If the number of shifts per day should be limited, equipment and space will become an important operating problem; if the number of shifts should be unlimited, then the supervisory staff will have to be increased. More supervisors will have to be obtained and trained. Moreover, in connection with direct workers, if the present level of production is to be maintained and the working day should be changed from nine to six hours, then the direct-worker requirement will be increased 50 per cent. It is fair to assume that the available experienced workers would not exceed 25 per cent, and that means a training or retraining problem for the remaining 25 per cent. In addition, the National Industrial Recovery Act implies an emphasis on training in several of its parts.

Since the way is now open for business and industry to organize further along trade-association lines, education and training in industry may become centralized and developed on a scale of large magnitude; in this case there should be some central coordinating agency, as, for example, the Chamber of Commerce of the United States, to serve as a clearing house in the study and dissemination of methods, procedures, and operating information.

There is every reason to believe that certain educational activities in the various companies or organizations in an industry might be far more effectively and economically centralized. Results never before attained might well be possible were present experience utilized.

For example, the railroads might offer an excellent opportunity for centralized training within certain areas of education and training in a way similar to the results obtained by the laundry industry. The course has been charted in several experiments; experience has been had; the results have more than justified expectations.

It is predicted that education and training will play an increasingly important part in business and industry in the coming years. This applies not only to the Central West, but to all parts of the country. If these predictions come true, then training must be planned and conducted with vigor. Naturally, these responsibilities will fall to the educational institutions and to industry itself. If training in or for industry is necessary for effective results, then we should discard our belief in magic and adopt sound methods and the scientific spirit in its organization and operation. No easy path opens up to any worth-while achievement. Intelligent planning and continued effort offer the only enlightened way, and this implies the application of educated and trained minds.



INDUSTRIAL EDUCATION *in the* EASTERN STATES

By OVID W. ESHBACH[1]

IN A PREVIOUS paper,[2] attention was called to the importance of evening educational facilities in large metropolitan areas and data regarding the extent and kind of participation in these activities were presented with reference to the New York area. The data were taken largely from the study of adult technical education, sponsored by the Chamber of Commerce of the State of New York, which was then in progress. Since that time the Chamber's report has been published and includes information regarding the need and influence of technical training in industry.

POINTS OF EMPHASIS

In most discussions of industrial education, interest centers about the types of programs in operation, their appraisal, the extent of training activities, trend of development, and the attitude or policy of management. In a recent publication, "Educational Experiments in Industry," by Nathaniel Peffer, published by the Macmillan Company, examples of specific programs are presented as a cross-section of training activities within industries concerned with employee education. For the industries represented, each of the foregoing subjects is discussed in Mr. Peffer's report. These subjects, with only casual reference to specific examples, will also be discussed in this paper.

TYPES OF EDUCATIONAL PROGRAMS

The term "industrial education" is usually very loosely used. In most cases it does not mean education as thought of in an academic sense but rather the training of employees in the efficient performance of their jobs. A classification of the majority of industrial activities inclusive of both educational and training objectives would broadly include the following:

(1) Training of new employees
  (*a*) Apprentice or vocational training
  (*b*) Introductory training both general and specialized
(2) Retraining and supplementary training of employed workers
(3) Training in leadership, including foreman training
(4) Educational activities, informative and academic in character.

While no attempt was made to place these in the order of importance, in most companies the first two are generally accepted responsibilities, the third is quite general in larger organizations, and the fourth decidedly rare. It is felt that the directness of objective and relative ease of appraisal of training as distinguished from educational activities have been largely instrumental in the more general acceptance of this responsibility. On the other hand, the value of education is most frequently associated with individual and personal development, and only indirectly with the efficient conduct of business, leaving the measure of achievement rather vague. It is, however, with this latter phase of the subject that this paper is chiefly concerned.

EXTENT OF EDUCATIONAL ACTIVITY

In the concluding chapter of Mr. Peffer's report, previously referred to, he makes the following comment:

> It is clear that education in industry and commerce is indispensable, no matter by whom done or how—education of some kind. It is clear that there is a great deal of effort for education in industry and commerce, whether wisely directed or not, efficient or not, broadening or narrowing.
>
> Industry recognizes the necessity of education. The mass of facts here presented is evidence of recognition and willingness to act on recognition. The expenditure these activities entail is proof of sincerity of conviction. It would be erroneous, however, to conclude from these facts that all industry is so committed and that what has been described here is typical. That is far from the truth. We have been discussing inevitably only that part of industry which does do something in education. We have not included all that is done, of course; many individual enterprises and programs have had to be omitted for various reasons. But even if all were included, the total would still constitute only a small segment of American industry. For the great bulk of industrial and commercial workers in the United States nothing is done by way of education, certainly nothing by the corporations or individuals who employ them. The majority of employers still believe that all this is just another "notion"—in part they may be right—and that workers can "pick up" their jobs as they always have—by observation and absorption. If not, they can be fired and others hired who will. The large amount of literature and speech dealing with the urgency of "selling" training to ownership and management and making them "training-conscious" is evidence that education in industry is still in the stage of promotion. And the converts are still in a minority. In fact, they are confined to the forward-looking, those who always are in the vanguard of movements based on new ideas.

A quotation from the "Survey of Adult Technical Education in the New York Industrial Area," follows:

> Generally speaking, industry is already training employees for the specific tasks which they must perform. Only in a few instances, however, do industries provide technical instruction of a general nature. On the other hand our technical institutes, with very few exceptions, do not provide training of a sort which aims to develop skill in repetitive tasks. As the situation exists, there is very little duplication of effort on the part of the schools, which, generally speaking, provide broad, general types of educational programs, and the industries, which provide specific training for specific jobs. This situation is unquestionably as it should be. As a further reason against the entry of industry into the field of general programs of education it may be repeated that the great bulk of industrial employees in the New York metropolitan area are with small companies, about half of them being with companies that on the average employ fewer than 20

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[1] American Telephone and Telegraph Company, New York, N. Y.

[2] "Adult Technical Education," by Ovid W. Eshbach. Paper read at the Annual Meeting, New York, N. Y., December 5 to 9, 1932, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Contributed by the Committee on Education and Training for the Industries and presented at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

men each. It is obviously impossible for a large number of these companies to provide effective technological instruction, even if they should desire to do so. An exception may well be made in the case of large establishments where certain technical knowledge is essential to their work and where the instruction given is adapted to their particular requirements.

As previously stated, the experience of the companies that have provided training and educational programs indicates that employees have thus been led to realize the values of additional education, and have enrolled in evening technical schools in greater numbers than in the case of employees of companies which have not provided educational or training programs.

It is likewise inevitable that industry, in becoming more technical in character, will require increasing attention to the training and education of employees. Together with the substantial personnel movement in industry, these factors are looked upon as future influences of considerable importance.

In the latter report information was obtained concerning technical instruction in 248 companies representative of a wide variety of industries. Of this group, only 70 offered courses of instruction for their employees. Instruction, particularly of a technical nature, was confined generally to large organizations. Of the 248 companies, 25 were large public utilities, 19 of which offered courses for employees. The remaining 223 companies were mostly manufacturing establishments, of which only 51 offered instruction to employees. These 51, likewise, were chiefly composed of larger organizations. As far as could be ascertained, very little organized instruction was conducted by industries, aside from a few large machine and metal manufacturers, manufacturers of basic products (including companies producing oil), power and light companies, gas companies, transportation companies, and the communications industry.

It is believed that the New York situation is fairly typical of the situation as a whole in the nine northeastern states of the nation. In these states there is a population of approximately 33,000,000 people, or slightly less than one-quarter of our total population. A large percentage of those gainfully occupied in this section are employed in industry. If distinction is made between business and industry, the former including banking, retailing, and distribution, the industrially employed group may be divided roughly into those employed in manufacturing organizations and those in service organizations, the latter including public utilities and city employees.

When it is considered that almost half of about 80,000 manufacturing companies in this section either have plants or offices in or near New York City, a survey of educational activities conducted by them should be reasonably typical of conditions throughout the area. The author, therefore, takes the privilege of quoting from the report of the Chamber of Commerce survey in which, as director, he attempted to obtain information from 1634 of the largest manufacturing establishments around New York. An inquiry was sent to officials of each of these companies requesting the following information:

(1) The number of employees and proportions of supervisory and non-skilled workers.

(2) The number of employees who would be benefited by different kinds of technical instruction.

(3) The nature of technical instruction offered within the company, if any.

(4) The number of engineering graduates employed each year in normal times.

A similar request was sent to about 150 architectural and building-construction firms. Representatives of other firms, such as public utilities, were also consulted and considerable information obtained by various means.

Specific information was received from 119 companies in all, of which 94 were manufacturing establishments. A summary of information obtained under item (1) and applied to the whole industrial group of the New York area is given in Table 1 by class of industry.

TABLE 1

Industrial Group	Number of companies	Number of employees	Percentage of supervisors	Number of supervisors
MANUFACTURING INDUSTRIES				
Textiles	11,876	282,076	3.2	9,026
Metals	4,141	206,584	5.1	10,505
Fabrics, fiber, etc.	4,951	144,399	4.7	6,786
Paper products	4,706	133,377	6.4	8,536
Foods	4,376	83,449	6.8	5,674
Chemicals	1,278	63,111	8.9	5,617
Machines	579	50,715	4.4	2,231
Basic manufactures	1,107	47,844	6.3	3,014
Wood products	1,704	44,251	7.3	3,230
Ceramics	835	24,558	5.1	1,253
Miscellaneous	1,047	40,686	5.2	2,116
Total manufacturing	36,399	1,121,050	5.2	57,988
SERVICE AND CONSTRUCTION INDUSTRIES				
Communication, power, transportation, and gas	31	265,322	10.0	26,532
Architects, engineers, building and allied industries (excluding building trade mechanics)	9,975	150,919	25.0	37,729
Power laundries and automobile-repair shops	6,903[a]	15,186	7.0	1,063
Total service and construction	16,909	431,427	15.1	65,324
Total for all	53,308	1,522,477	8.0	123,312

[a] Not including hand laundries, gas stations, and similar non-technical establishments.

Information obtained under item 2 is summarized for manufacturing industries only, in Tables 2 and 3.

The nature of instruction given by companies, item (3), summarized by industrial groups is given in the Survey report.[3]

THE TREND

While it is impossible at a time of industrial paralysis to determine or even make a reasonable guess as to future interest and development of industrial education, an appraisal of the situation over a longer period of time may throw some light on future possibilities. Furthermore, discussion may not be confined to education within industry but must inevitably be associated with the development of all educational activities sponsored for the convenience of the employed. Among the agencies to be considered are correspondence or home-study programs, evening or night schools, cooperative courses, and libraries.

The large-scale industrial operations of the last half-century have caused considerable organized educational activity within industry, from which the idea of "corporation schools" developed. The growth in these activities both here and abroad was quite rapid and resulted in the formation of a National Association of Corporation Schools. To what extent this development was helped by the lack of evening schools is problematical, but certainly the rigid conception of instruction thus provided must be modified in the light of

[3] Quoted in original paper, but omitted in this publication. The industrial groups are textiles, metals, fabrics, fibers, rubber, leather, vegetable, and other natural substances, paper products, foods, chemicals, machinery, basic manufactures, wood products, ceramics, and service organizations.

TABLE 2 INDUSTRIAL GROUPING OF EMPLOYEES WHO WOULD BENEFIT FROM TECHNICAL INSTRUCTION

Group	Number of companies reporting	Number of employees	No. who would benefit	Per cent
Textiles	8	1,384	15	1.1
Metals	26	6,500	1,093	16.8
Fabrics, fiber, etc.	4	825	0	0.0
Paper products	9	1,640	210	12.8
Foods	7	8,767	742	8.5
Chemicals	14	2,178	203	9.3
Machines	9	6,092	517	8.5
Basic manufactures	10	26,795	6,674	24.9
Wood products	3	575	43	7.5
Ceramics	4	1,022	68	6.6
Total	94	55,778	9,565	17.2

TABLE 3 EMPLOYEES OF 94 MANUFACTURING ESTABLISHMENTS WHO WOULD BENEFIT FROM TECHNICAL INSTRUCTION

Course	Number of employees
Architecture	67
Automotive engineering	2104
Building equipment and construction	88
Chemistry and chemical engineering	973
Civil engineering	105
Drawing and drafting	462
Electrical engineering	534
Heating and ventilating	1162
Industrial engineering	206
Mathematics	495
Mechanical engineering	2205
Metallurgy	136
Physics	402
Petroleum technology	150
Refrigeration	146
Salesmanship	85
Baking technology	85
Wood technology	75
Miscellaneous	85
Total	9565

(Total number of employees in companies reporting = 55,778.)

later development of educational facilities. During the War period, 1913 to 1921, this organization grew in numbers and influence, helped largely by conditions of labor shortage and large industrial profits. In fact, the movement was not confined to manufacturing establishments alone but was taken up by banks, insurance companies, department stores, and financial organizations, and in 1922 resulted in the formation of the National Personnel Association through a merger with the Industrial Relations Association of America. The following year this organization became the American Management Association, through the activities of which problems of training and industrial education have received attention.

External to industry in the field of education, recent years have seen considerable development. Not only have the number of institutions and attendance in day schools increased out of proportion to industrial and other developments but the facilities for the education of the employed have placed almost every conceivable form of education at their disposal within the larger metropolitan districts. In the nine northern states the four largest industrial areas are Pittsburgh, Philadelphia, New York, and Boston, in each one of which may be found well-developed programs of evening education. At least a dozen institutions in the field of engineering education alone offer the finest kind of instruction to employees, including college graduates, after working hours. To these may be added over a hundred good technical trade and vocational schools. In each of these areas, likewise, cooperative engineering courses have been successfully conducted over a considerable number of years.

All of these activities, it seems, should have the effect of interesting employees and management in educational development with the result that the facilities of educational agencies, whether in industry or not, are used more extensively and effectively in providing the kind of instruction individual and industrial needs require.

In the less thickly populated industrial sections other means must be resorted to. It may be that the industrial establishments in these areas will find it necessary to handle a large portion of the employee education. On the other hand, two large state institutions have for many years conducted extension courses and have ably met many of the training requirements of these and other companies.

INFLUENCE OF MANAGEMENT

Management in the last decade has recognized a trusteeship for the principles and ideals of the personnel movement and promise of permanence and improvement is attested by the records of these trying times. It is a fair assumption that in the years to come opinion regarding the values of education within industry will be more clearly crystallized; today opinions differ widely, and education sponsored internally is so small as to warrant the statement that almost all of it is confined to reasonably large establishments.

Aside from the influences of the personnel movement and the growth of adult education, industry and education should recognize two responsibilities. The first has to do with the attitude of employees with regard to learning while working, and the second with requirements brought about by changing conditions.

The desire to learn is the foundation upon which the extension and value of education rest. Employees may be artificially motivated to study, but nothing lasting is accomplished unless the necessity is clearly emphasized both through use and added responsibility.

In the recent study of adult technical education in New York by the Chamber of Commerce, it was clearly illustrated that the attitude of employers has a great influence upon the initiative of employees in seeking further education. The simple fact that the great majority of evening students is employed by companies having training programs suggests more than a possibility of substantial participation in education, should company officials make it part of their responsibility to encourage employees to take advantage of educational opportunities.

Now there is a second viewpoint that has to do with a more intangible but no less real objective when viewed over a long period of time. It has to do with social and industrial conditions of a constantly advancing civilization. The time is past when people can be ordered to do this or that without questioning why. A most striking example is our present situation. The desire to understand the intricate working of business, finance, etc., is almost universal. Every one has been affected and the response to demands upon management will be in direct proportion to the intelligence and understanding of employees. Loyalty, no matter how great the sacrifice involved, is founded upon confidence, and confidence cannot prevail permanently in an atmosphere of ignorance.

Anticipation of the interests and requirements of our employed population and cooperation and understanding between industry and education are essential to a better knowledge of the problems of an evolving civilization.

INDUSTRIAL EDUCATION *in the* SOUTHERN STATES

By THEODORE S. JOHNSON[1]

IN ORDER to understand fully the present status of education in industry in the South, it is necessary to have a proper perspective of the past history and present development of industry in general in the South and of the educational progress of the same area.

As for industry, it is significant that in the early part of the nineteenth century and for the half-century marking the transition from the eighteenth century, the industrial development of the southern part of the United States was perhaps even somewhat in advance of that of the northern states. There developed soon, however, a tendency to turn to agricultural pursuits and so the three decades prior to the war between the states marked the almost complete submergence of industry and the firm establishment of agriculture, developing a landed aristocracy and "poor-whites," built upon the production of cotton, rice, tobacco, and ship stores, with the aid of slave labor.

BEGINNINGS OF INDUSTRIAL DEVELOPMENT IN THE SOUTH

The war between the states, which marked the real beginning of the industrial development of the North, also marked the end of the era of large estates in the South. The exchange of experiences, perhaps even the invasion of the Union troops itself, served to call Southerners to a new realization of the potential resources of the region. Although delayed for a quarter of a century by the problems of the reconstruction era, the trend to greater industrialization has made tremendous strides in the last three decades.

Led first by the primary conversion industries, textiles, tobacco products, lumber, and furniture, and, in a few localities, but of great importance, the steel and iron industry, the area is marked by the most active industrialization progress, proceeding at nearly twice the average rate for the United States. It is important to note in this connection that in general the manufacturing industries are being developed on a much less congested scale than that marked in northern United States. The result is a more widespread distribution of small manufacturing towns, which enjoy the combined benefits of rural and urban society with the resulting economies. In 1919, in six southern states, manufacturing produced in cities of populations greater than 25,000 was 35 per cent of the total as compared to 77 per cent for Illinois, 70 per cent for Massachusetts, and 51 per cent for Pennsylvania. The distinctive industrial area is largely limited to a horseshoe-shaped region in the Appalachian Piedmont of Virginia, North and South Carolina, Georgia, and Tennessee, in which will be found a large number of relatively small and scattered industries, operated in the midst of a rural population. In 1920 there were twice as many people in proportion in the area engaged in agriculture, forestry, and animal husbandry as for the United States as a whole, while for industries for the extraction of minerals, manufacturing, and mechanical processes, transportation, and the like, in general, the proportion of people employed in these industries was only half the national average.

As a result of these conditions, it may be said there is no widespread or general industrial atmosphere. The industries, except in a few instances, have been developed in small units and in general are not the predominating commercial influence. The progress of industrialization was slow at first and only within the last two or three decades has it been rapid enough to tend to produce any large industrial classes.

In textiles there are now several communities in the Piedmont section of Virginia, North and South Carolina, and Georgia, where mills have been built in sufficient numbers and of sufficient size to give a definite industrial character to the communities. In the coal- and iron-ore mining regions of Alabama, Tennessee, and Virginia, the phosphate-rock industry in Florida, paper pulp at Canton, N. C., furniture manufacturing in Virginia and North Carolina, similar industrial centers have attained importance enough to prove exceptions to the rule above stated.

It is evident too, that with the exception of the iron and steel centers, where secondary enterprises have been established to use the products of the primary conversion industries, and of a relatively small percentage of the employees of the other concerns, the great proportion of employed persons are engaged at occupations that do not require extensive technical knowledge or great skill. In the textile industry, for example, the principal emphasis was at first placed on the production of staple coarse goods, and only within the last twenty years have the mills turned their attention to finer goods and more intricate processing and specialties, requiring more skilful operations.

EDUCATIONAL STATUS OF THE SOUTH

As for the educational status of the southern area, something of a similar nature has taken place. While some of the higher institutions maintained high standards through the years of reconstruction and afterward, in general, public education was greatly retarded. With the turn of the century, under the inspired leadership of a few men, great progress was begun and continued until the depression. In 1914 there were only 16,800 pupils in high schools of North Carolina, while in 1930 there were 101,500. These figures can be duplicated by nearly all the states in the South, and are referred to here in order to show that the growth of industrial education since 1917 can only be understood properly in the light of knowledge of the industrial and educational development of the area as a whole.

However, in spite of the fact that the development of both industry and education has largely taken place in the last 15 or 20 years, it is true that this development has been almost phenomenal. Attracted by favorable topography, mild climate, abundant natural resources, raw materials, labor, abun-

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Contributed by the Committee on Education and Training for the Industries, and presented at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

dant and well-distributed power, and good local markets, there is every reason to expect not only a continued sound growth of existing industries, but a greater diversification of manufacturing, chiefly among the secondary or processing plants.

In Alabama, during the year ending July, 1933, there were 308 industrial classes conducted in the state with a total enrolment of 5824 as compared with 8728 for the previous year. Most of the decrease was in evening classes, while all-day and part-time enrolments increased, a common change in depression periods. The evening classes increase as the industrial activity increases. The largest concentration of work in Alabama is conducted in the Birmingham district. Due to an unusual combination of circumstances, the program has been very seriously handicapped, but the educational organization has been maintained. There are more than 80 "centers" in which classes can be organized as soon as funds will permit.

In Florida there is reported a great increase in interest in and appreciation of industrial training. Much of the work is conducted among hotel workers, barbers, and firemen, less attention being paid to trades of more industrial character. This is, of course, due to the relatively limited number of manufacturing industries located in the state.

In North Carolina the number of classes has steadily increased from five in 1918–1919 to a peak of 398 in 1930–1931, dropping to 379 in the last year. The enrolment at the corresponding periods was 128, 6025 in 1930–31, and for the current year 5984. These include for the most part textile classes, classes in pulp and paper plants, aluminum plants, and many general classes in cities. There is a great demand for general continuation courses, mostly along commercial lines.

In Tennessee there has been a great decrease in enrolment during the current year, the mortality being especially heavy in centers where classes have been offered for the past eight or ten years. Classes newly organized have shown a good enrolment and exceptionally good attendance. Classes are conducted for coal miners, for manufacturing, employees of public utilities, ice manufacturers, milk industries, rayon, and textile mills. Course subjects include auto mechanics, cotton-mill mathematics, machine drawing, blueprint reading, furniture design, process chemistry, practical electricity, pulp and paper manufacturing, rayon chemistry, metal fabrication, loom fixing, refrigeration, and electrical apparatus. In addition to these, which were conducted in industrial plants, these same subjects and other related ones were conducted in public-school buildings in the industrial centers.

In Virginia 322 trade and industrial courses enrolling 9711 men and women, representing 32 vocational pursuits were conducted last year. In the day trade classes about three-fourths of the time is spent upon the acquisition of trade skills and related trade information. Considerable emphasis is being placed on foremanship conferences and foreman training. The enrolment in all classes has shown a great increase in spite of, or possibly because of, the depression. Classes conducted in coal-mining, railroad, furniture, and textile centers make up the largest proportion of the work.

TRAINING IN THE TEXTILE INDUSTRY

Since by far the largest and most important of the industries of the South is the textile industry, it will be of interest to consider some of the work done in these subjects. Originally, the industry confined its attention to plain yarns and coarse goods, requiring a minimum of skilled labor. Many operatives came from the older textile centers of the North and gradually there was built up by actual mill training a body of men large enough to operate the relatively simple processes. With the extension of the industry and the development of finer yarns and finished products, it has been necessary to add special training, most of which has come through the trade and industrial classes. These are made possible through Federal appropriations under the Smith-Hughes law. The growth of these classes since 1917 has been very great.

The first courses consisted of little more than arithmetic taught in cotton-mill terms. Much of this foundation work was required at first, but soon courses were offered in mechanical calculations, draft calculations, and calculations required in carding, spinning, and weaving. Later, courses were given in more and more advanced textile subjects, such as loom fixing, knitting machines, dyeing, and finishing.

The most notable advance was made by the adoption of standardized courses by most of the cotton-manufacturing states. This provides for standardized courses in textile subjects and standardized credit cards and diplomas. In North Carolina alone, textile classes increased from five in 1919 to 130 in 1921 and have gradually increased to 160 or more in the last year.

The use of the standardized courses permits the continuation of studies for those who change their localities and makes possible a more uniform teaching personnel and better methods. The courses range from cotton-mill mathematics and mechanical calculations to calculations for cards, drawing frames, sliver lappers, combers, fly frames, spinning frames, twisters, spoolers, warpers, slashers, and looms to cloth analysis and design. Courses are offered also in "fixing" for all these processes. These courses make possible for employees who avail themselves of the opportunity presented complete and graduated courses in every phase of textile work. Coupled with the foremanship courses, they make possible the almost unlimited advancement of the worker.

IMPORTANCE OF TRAINING UNSKILLED WORKERS RECOGNIZED

Most of the leaders of industry recognize the importance of training the unskilled worker for better work and better pay. Most of the workers, particularly in textile and other manufacturing centers, may be classed as skilled workers who seek further advancement and better understanding of their work.

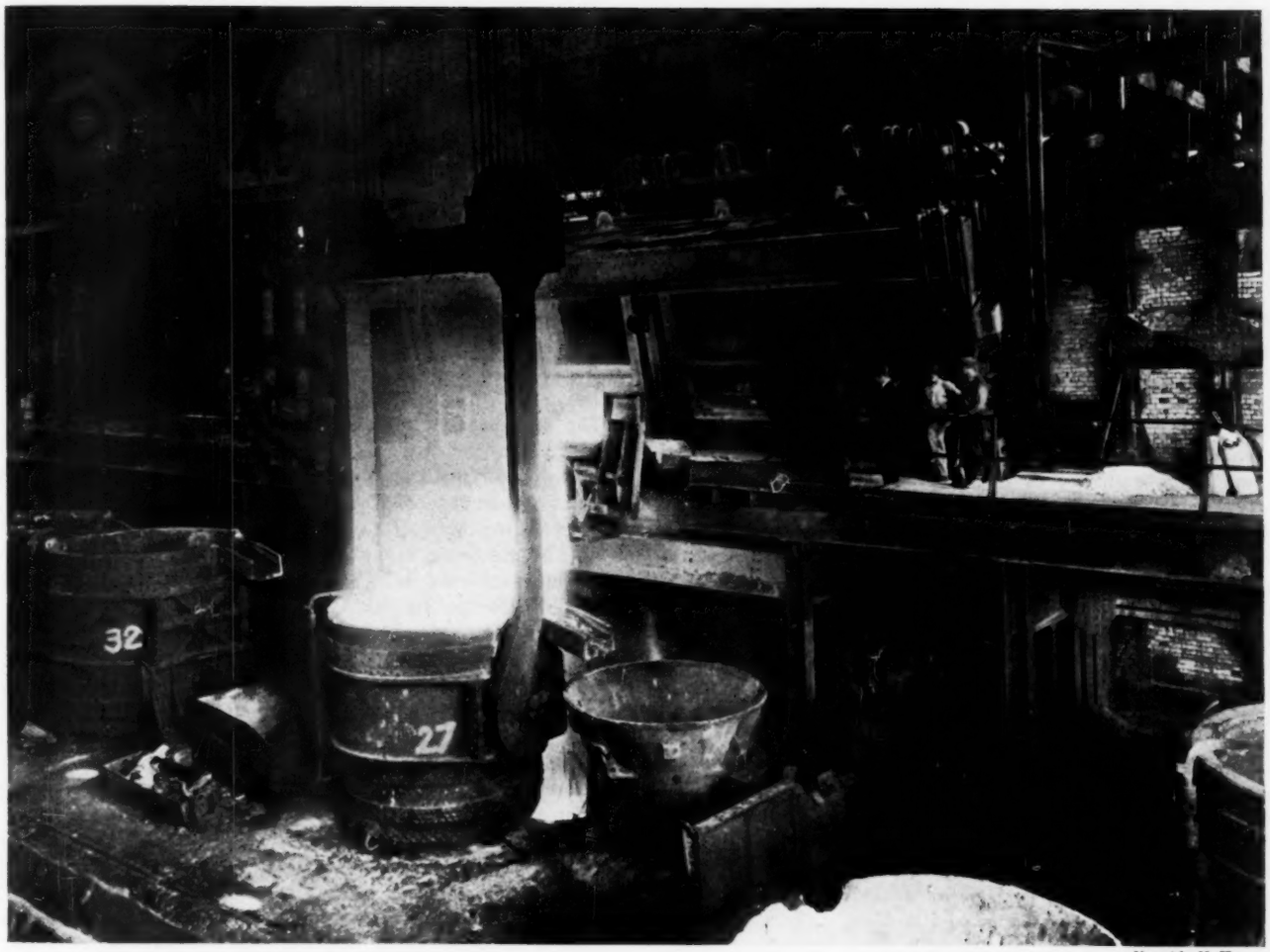
In the beginning it was found difficult to enlist the interest of the workers, but with the growth of the movement, this difficulty has largely disappeared. The owners with but few exceptions have always given the most cordial cooperation and support.

The optimum size of classes has been found to be from ten to fifteen, usually nearer ten. Approximately one-tenth of the employees use the schools where they are well established. The course usually runs for 20 weeks during the winter months, with a total of from 40 to 80 hours of instruction.

Many other industries of considerable monetary and commercial importance in the South are operated with few skilled workmen, most of the required labor being considered unskilled or involving only routine—usually manual skill and dexterity. These depend for the most part upon the general education to be supplied by the public schools. In some isolated cases all through the region, where some special industry has been developed to the point of employing large numbers of workers, the need for special training has arisen, and in these cases, industrial classes have been organized.

A striking example of this, and one to which much merited attention has been drawn, is the course of technical instruction offered at the plant of the Champion Fibre Company, at Canton, N. C. Here, under the guidance and cooperative efforts of the president of this company, courses in pulp and paper

(*Continued on page 244*)



Nesmith, N. Y.

Automatic Control of METALLURGICAL FURNACES

By H. J. VELTEN[1]

METALLURGICAL furnaces, such as the open-hearth steel-melting furnace and the furnace for heating semi-finished steel, present, in general, operating conditions more difficult to meet than those met with in the operation of other furnaces.

Automatic control of the open-hearth furnace has several aspects, including (*a*) control of rate of use of fuel, either at a definite rate, or in accordance with the desired temperature; (*b*) regulation of furnace pressure; (*c*) control of shape, size, and position of flame; (*d*) regulation of air supply in relation to fuel so as to produce a definitely varying volume of products of combustion; (*e*) regulation of proportions of liquid and/or gaseous fuels, where two or more fuels are used in combination; (*f*) regulation of flow of exit gases so as to proportion distribution of heat between air and gas regenerators; (*g*) regulation of the interval between reversals in accordance with an impulse of temperature or differential temperatures between incoming and outgoing regenerators.

Control of a steel reheating furnace includes (*a*) regulation of temperature; (*b*) control of atmosphere within the furnace with respect to its content of combustible gases or oxygen; and (*c*) the shape and position of the flame. It may also be desirable to regulate one or more of the conditions as specified for the open hearth. In this case the means are generally the same as are hereafter described for the open-hearth furnace.

Evidently, automatic regulation of furnace conditions should logically commence with fuel regulation in accordance with a

[1] H. A. Brassert and Company, Chicago, Ill.

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temperature impulse. Such regulation is technically difficult for two reasons: First, that of lag between fuel regulation and resultant temperature; and second, the difficulty of identifying the desired furnace condition with an obtainable impulse of temperature. The first of these conditions may be completely met. The second is now the subject of investigation in many places, and indications are that a formula for identifying the resultant furnace condition with one or more temperature impulses will be reduced very shortly to practical use.

REGULATION OF THE OPEN-HEARTH FURNACE

Regulation of furnace pressure is in reality a regulation of flow of outgoing gases at a rate which corresponds exactly with their formation. This regulation, in order to be useful, should be as accurate as possible, since very small variations in pressure produce considerable changes in flow. Accurate regulation of furnace pressure results in an avoidance of infiltration of cold air, while at the same time it maintains a constant shape and size of flame, promoting continuous heat transfer and avoiding unnecessary wear on the furnace walls and ends.

Control of shape and size of flame is effected by the size and shape of the gas port, where gaseous fuels are used, and by the use of a regulated burner where liquid forms all or a part of the fuel. Such fuels are invariably atomized by steam, and automatic control of the oil-steam ratio in a correctly designed burner assembly permits regulation of the size, shape, and position of the flame.

Regulation of the air supply is most simply and reliably effected by a regulation of ratio between fuel and combustion air. In the open-hearth process, means must be provided for varying the ratio at successive stages of the process. This may be done manually or by an impulse varying with the oxygen content of the products of combustion. The requirements of length and shape of flame preclude the possibility of instantaneous combination of fuel and air. The gas and air ports are so shaped that the air meets the outside of a gas body, and the length and shape of flame, as well as its temperature, depend on other factors than the amount of surplus air. However, such surplus has the bad effect of increasing the volume of products of combustion, increasing the carry-over of slag vapors to the regenerators, decreasing the efficiency of the latter, and, for these and other reasons, adding to the fuel requirement and increasing the cost of repairs.

The open hearth is often operated on a mixture of fuels. These may be blast-furnace gas and coke-oven gas, coke-oven gas and tar, coke-oven gas and oil, blast-furnace gas and oil, blast-furnace gas, coke-oven gas, and liquid fuel, or blast-furnace gas, coke-oven gas, and producer gas. Other combinations of these fuels are possible, the combinations being made sometimes for the sake of technical result and sometimes on account of the availability of the fuels or of one of them. Where combinations exist the regulating system should be able to produce the following effects:

(*a*) Maintain a constant heat input to the furnace by automatically replacing one fuel by another in the event of a shortage of the first.

(*b*) Permit regulation, by one adjustment, of the total heat input.

(*c*) Summarize the air required for combustion of all the fuels and regulate a single air fan so as to provide the correct supply, maintaining the correctness of the air supply in case of variation in the supply of one or of all the fuels.

Means to all of these requirements of regulation are completely worked out and are available.

The shapes of gas and air ports of the open-hearth furnace are usually designed with reference to conditions during the inlet phase of the process. Invariably, the tendency at the outgoing end is to put too much gas through the air checkers. This may be avoided in some degree by varying the construction, but depends on regulation of dampers in the outlets of the two checker chambers for complete adjustment. The impulses are those of comparative temperature in the regenerator flues.

Automatic reversal is not automatic regulation in the sense in which it has been used in describing continuously maintained conditions. It is rather a determination of time for the reversing operation in accordance with an impulse of temperature or differential temperatures.

REGULATION OF THE STEEL-HEATING FURNACE

The steel-heating furnace varies from the open-hearth in the details of the problems of regulation presented and in the desirability of maintaining an atmosphere in which scaling of steel will be reduced to a minimum. This atmosphere may be maintained by regulation of the ratio between fuel and air with the resulting atmosphere checked by intermittent or continuous analyses, or by an impulse varying with the content of combustibles in the products of combustion. An oxygen or CO_2 impulse may also be used for this purpose. The technical results obtainable by regulation of atmosphere are among the most important obtainable by automatic regulation.

FURNACE-PRESSURE CONTROL

It will be recognized that automatic control as specified in the foregoing sections has in many cases passed the point of regulation of a single condition merely, and has reached the stage where it deals with maintenance of relative conditions in a somewhat complicated system. Details of the methods whereby these relative conditions are maintained might be given at great length. Considerations of space prevent so extensive a discussion. However, in the following, a few details of control problems on metallurgical furnaces will be discussed.

The basic factor in most of the regulation is undoubtedly the control of furnace pressure. Some other factors, as, for instance, combustion control, depend upon the absolute maintenance of a constant furnace pressure. This is generally regarded as possible with a very simple application of any controlling device. But a closer investigation will show that a perfect furnace-pressure control is, in many cases, difficult to achieve, as the pressure should be maintained within 0.005 in. of water for the reasons previously stated.

The oldest well-known type of draft control is the bell-type direct-operating regulator, which actuates a butterfly valve in the flue or in a side inlet. A simple calculation shows that with a bell area of 5 sq ft, for instance, a variation of about $^1/_{25}$ in. of water of the regulated pressure is required to produce an operating force of 1 lb. The impulse for these regulators is therefore taken in the flue, where a high negative pressure is available. The furnace pressure will thereby vary considerably with the load. For this reason, the direct-operating draft regulator has been replaced by those operated by auxiliary power, which may be electricity, liquid, or air. The impulse system which is then only actuating a control relay can be made sensitive enough to react upon the slightest variation of the pressure in the furnace itself.

The most common impulse systems used for this purpose are the submerged bell and the diaphragm. The bell has the advantage of using the full area for transmitting the impulse to the control relay, while with the ordinary diaphragm, only

about one-third of its free area is effective for the impulse transmission. To increase the effective area, the diaphragm for such low pressures is equipped with a metal ring at its center. The advantage of the diaphragm impulse system is its small volume combined with a minimum of travel, so that, with any impulse variation, practically no gas flow occurs, but merely a transmission of static pressure. This is an important factor for the stability of the regulation.

A second and equally important factor is that the regulating speed shall be a function of the impulse. With any installation of furnace-pressure control, it must be determined whether the existing time lag between operation of the controlling device and its effect measured in the furnace is within the limits of stability of the control. If not, an outside stabilizer must be applied to counteract any impulse variation transmitted to the control relays or to the motion of the controlling device. Such a stabilizer is always necessary when a damper between a waste-heat boiler of an open-hearth furnace and the stack is to be operated for maintaining the furnace pressure. For the sake of accuracy of the draft control, the stabilizer should not permit any permanent variation from the desired value, i.e., it should reset the original adjustment of the regulator after any control motion.

COMBUSTION CONTROL

As to combustion control on a metallurgical furnace, a single example, namely, the regulation of combustion air supply for several fuels, will be given.

Fig. 1 shows two fuel-gas lines and transformers producing an impulse which represents the total demand for combustion air for both gases. This impulse is used as the primary one for the combustion regulator, the secondary impulse of which is the volume of combustion air supplied to the furnace. The transformers must be able to receive a constant flow of air and to give out a flow which varies with the primary impulse. Both gases are measured by means of orifice plates. The differential pressure in line I actuates the primary diaphragm of transformer I. The amount of air flowing into pipe 2 depends upon the position of the transforming device, which in turn is set by the gas-flow impulse. A small orifice 3 measures the amount of air going through pipe 2 and the differential pressure across this small orifice actuates the secondary diaphragm of the transformer. Therefore, any variation in gas flow will change the setting of the transforming device until primary and secondary impulses are in equilibrium. In other words, the air flow through orifice 3 is proportional to the flow of gas I. In the same way, the air flow through orifice 4 is proportional to the flow of gas II. The total of these air flows passes through orifice 5 and the impulse on orifice 5 represents the demand for combustion air for both fuels. It is taken as the primary impulse to any combustion regulator which controls the supply of combustion air so as to maintain a constant ratio between the total volume of fuel and combustion air. Any additional gaseous or liquid fuel may be handled with this control arrangement.

By an extension of the same principle of summarization, it is possible to maintain a constant heat input to the furnace, the regulating system automatically compensating for a shortage in one fuel by an increase in the other. In this case a gaseous fuel will be regulated by a flow control. The flow of this gaseous fuel and of an auxiliary fuel, which may conveniently be liquid, are summarized, and the impulse which corresponds to the combined flow is used to regulate the flow of liquid fuel. The liquid fuel will therefore be used in sufficient quantity to furnish the desired impulse of total heat input. This impulse

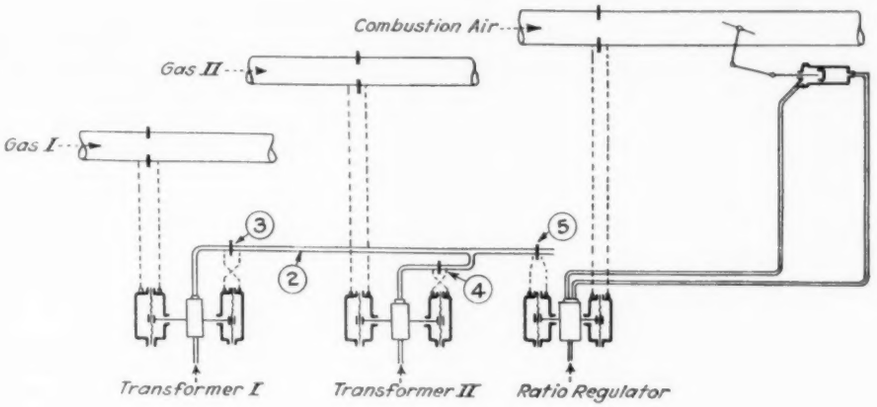

FIG. 1

may also be used as shown in Fig. 1 for the regulation of total combustion air.

CONTROL OF FURNACE ATMOSPHERE

Recent researches by Murphy, Jominy, and Upthegrove in the United States and Schroeder in Germany have shown the extreme importance of control of furnace atmosphere in heating steel and the advantage in avoiding excess oxygen in the furnace atmosphere, particularly where the products of combustion consist largely of water vapor. A slight sacrifice of economy in the form of a few per cent of unburned fuel may be much more than compensated by a saving in scale formed on the heating steel. Regulation of the furnace atmosphere may be accomplished by maintaining a ratio between fuel and combustion air. Such a system takes no account of variation in the composition of the fuel gas or leakage of the furnace system, and is therefore inaccurate in accordance with the magnitude of these variables. Regulation may also be accomplished by means of an impulse which varies with the composition of the atmosphere. The impulse may be electrical, resulting from the combustion of fuel gas contained in the flue gas or from combination of contained oxygen with fuel gas used as a reagent, or it may be one of specific gravity. The direct application of such an impulse to the regulating valve by means of a relay will not afford satisfactory regulation, on account of the fact that the regulating impulse is subject to considerable lag. The preferable method is by means of volumetric control of air and gas in a ratio to each other which is determined by an impulse varying with the content of combustible air, or CO_2, as the case may be. Such a system, shown in Fig. 2, gives accuracy and stability.

CONTROL OF FURNACE TEMPERATURE

Another interesting control application on metallurgical furnaces is the regulation of the furnace temperature. This is fundamental to a complete automatic furnace operation. Fig. 3 shows diagrammatically the arrangement of a temperature control. Extensive tests on the measuring of furnace temperature are now being made and the optical pyrometer seems to be the most successful means of obtaining a reliable tempera-

ture impulse. In Fig. 3, the optical pyrometer is indicated at 2. The temperature impulse is transmitted to a metering system 3 which may be a potentiometer or any other system actuating a transforming device and balanced by a counteracting air-operated diaphragm. The transforming device will always be in such a position that pressure resulting from the temperature impulse and the air pressure in pipe 4 and on diaphragm 5 are in equilibrium. The air pressure in pipe 4 is therefore proportional to the temperature to be maintained and is transmitted to the pressure-type regulator 8, which actuates a control valve in the fuel supply line to the furnace, so as to maintain a constant air pressure or a constant furnace temperature.

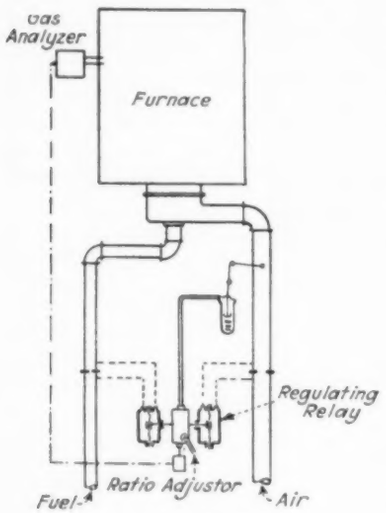

FIG. 2

This regulation would be sufficient for an ordinary temperature control if a considerable lag, due to the heat capacity of the furnace, were not encountered, as is, however, the case in most metallurgical furnaces. An analogy to this is the speed regulation of a turbine by means of the turbine governor, the turbine speed being here the temperature, and the inertia of the rotating masses being the heat capacity of the furnace. In both cases, the regulation must be stable. Mathematically, it may be expressed as the equation of harmonic motion:

$$m\frac{d^2x}{dt^2} + a\frac{dx}{dt} + bx = 0$$

with decreasing amplitudes, where x is the deviation from the adjusted value, a the damping factor. This means that the regulator should not only be influenced by the variations from the adjusted value but also by an impulse representing the speed of the variation. Practically, it can be accomplished in a simple manner by providing a resistance, for instance, a system of capillary tubing, between pipe 4 and diaphragm 5, and measuring the flow of air through this resistance. In order to create a measurable flow, the diaphragm chamber is increased by a submerged bell 7. An indicating gage 9, connected to the diaphragm chamber, will read the furnace temperature and its variations, while a differential gage 10, connected to both sides of the resistance, shows the speed of the temperature variations. Acting upon the regulator is the sum of both, corresponding to the equation

$$a\frac{dx}{dt} + bx = -m\frac{d^2x}{dt^2}$$

Thus a stable regulation can be obtained without making use of the potential energy or accumulating effect of the furnace, i.e., without permanent variation in the regulated value. In special cases, the regulator may be equipped in addition with an isodrome, or single-point stabilizer, as previously mentioned, for the furnace-pressure control.

The regulator has the tendency not only to maintain the adjusted temperature, but also to bring the speed of variation immediately back to zero, so that a balance between heat input and heat consumption is always maintained. With a slight variation in temperature, a rapid and considerable change in heat input takes place, but only for a short time, namely, until the speed of variation becomes zero. This is what a careful operator would try to accomplish by regulating the fuel supply manually in accordance with the furnace temperature.

The temperature regulator may control either the gas or air supply provided a combustion control is applied as previously shown. With especially favorable conditions and on small furnaces, the fuel and air valves may be interconnected. The condition for successful application of this method includes constant pressure of fuel and air, the same valve characteristics, and the same resistance between valves and furnace. These conditions seldom exist and a separate combustion regulator is therefore required in most cases.

CONCLUSION

Past attempts to apply automatic regulation have, in many cases, been limited to a single condition, most usually that of furnace pressure. Comparatively few installations have been made in which the control of the rate of use of fuel, of the furnace atmosphere, and of the furnace pressure have been simultaneously effected. In some cases where ambitious schemes of regulation have been attempted, technical shortcomings in the control equipment have prevented full realization of the expected results. At the present time, however, adequate methods and equipment are available for the regulation of the conditions enumerated at the beginning of this paper. Accurate determination of the economic results obtained by regulation are difficult, since no metallurgical operation is completely stable with respect to conditions other than those which are regulated. Careful tests indicate a saving in fuel in excess of ten per cent in the open-hearth furnace, with resultant advantages of higher production, reduced repairs, and a product more nearly in accordance with the specifications of composition and quality. It may be definitely expected that in the near future all furnaces will be regulated with respect to the important conditions of fuel flow, furnace atmosphere, and furnace pressure.

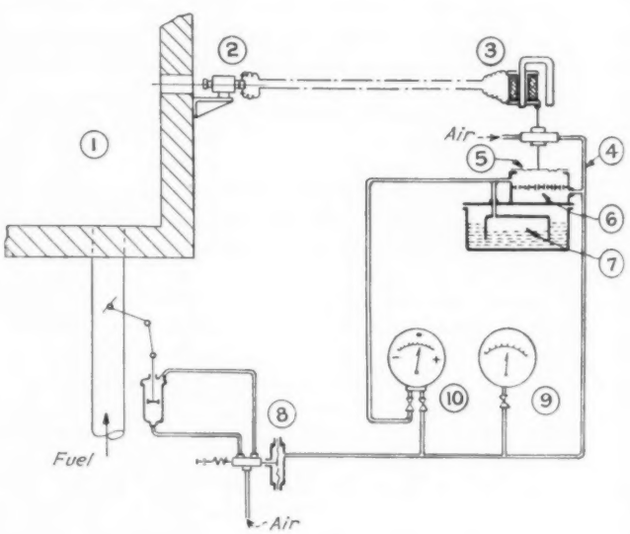

FIG. 3

PLANING *Versus* MILLING

Discussion at A.S.M.E. Annual Meeting of Three Papers Published in November

A SYMPOSIUM entitled "Planing Versus Milling," was one of the contributions of the Machine Shop Practice Division to the 1933 Annual Meeting of The American Society of Mechanical Engineers. The papers which made up the symposium were printed in the November, 1933, issue of MECHANICAL ENGINEERING, pp. 673 to 684.

In this symposium the point of view of the shop executive was expressed by A. C. Danekind, mechanical engineer, Manufacturing General Department, General Electric Company, Schenectady, N. Y., whose paper ended with the following conclusions:

No hard and fast rule can be offered. All influencing factors governing each individual job must be considered before an accurate analysis can be made. It should be noted also that this paper has been based chiefly on the conditions involved in machining moderate or "in-between" sizes of pieces, for therein lies a field for both planers and milling machines. In spite of the fact that many pieces are now being milled which were at some time or other planed, there can be no question relative to the value and usefulness of the planer. In certain cases the facilities offered by a planer are such that a particular condition can be met by no other machine tool; for example, some semi-concealed surfaces can only be machined with an off-set single-point tool.

A careful survey of conditions in one large plant reveals the fact that many jobs have been transferred from a planer to a milling machine, but in no instance do the records of this plant indicate the changing of a job from a milling machine to a planer for economic reasons. Milling machines are by far the more popular type of equipment in these days of never-ending effort for lower manufacturing costs. This fact is at least partially recognized by one manufacturer of planers in the announcement of a new machine incorporating all the features of an up-to-date planer with the addition of two motorized milling heads mounted on the rails.

The greatest single recommendation for the operation of a planer today is its broad flexibility, and for that reason, if for no other, it will always be a real factor in general machine-shop practise.

The case for planing was set forth by Forrest E. Cardullo, chief engineer, The G. A. Gray Company, Cincinnati, Ohio, member, A.S.M.E. Confining his remarks to modern planers, Mr. Cardullo discussed the subject from the points of view of the rate of removing metal, the metal removed per minute per horsepower, pieces produced per day, first cost, versatility, accuracy of work produced, and finish, and described the so-called "milling planer" and its work.

R. E. W. Harrison, member, A.S.M.E., presented the case for milling. His paper was a comparison, based on economic considerations, of the two methods, considered under such general topics as work-handling facilities, versatility, accuracy, finish, finish required after machining, machinability, rates of metal removal, change-over time, first cost in relation to rate of production and upkeep, tooling first cost and upkeep, and the actual tooling cost of removing metal by the milling process.

At the meeting at which the papers were presented, considerable discussion resulted. The discussion follows:

B. P. GRAVES SEES GREAT ADVANTAGES IN MILLING MACHINES

B. P. Graves[1] spoke as follows:

The question of milling versus planing is always foremost in the minds of design and production engineers. Both the milling machine and the planer have a prominent place in the metal-cutting industry, but the milling machine can and will be used to great advantage on work that has always been classed as planer work.

For many years we have worked with the thought in mind of milling wherever possible, and we have been most successful as to results, both in quality of work and in production costs.

We realize that certain classes of work must and can best be handled on a planer. To justify this realization, we are equipped with a large planer department, but in spite of this, we mill in many cases where, in the ordinary run of shops, the parts would be planed.

For example: The castings for the beds of our screw machines are rather complicated in form, having dovetailed ways, half bearings, and several different planes to be finished. This work is being handled entirely on milling machines. Guide ways and seats for mechanism on grinder beds are all milled, and only recently we purchased a large four-spindle milling machine to take care of our larger size of grinder beds. Most of our milling-machine saddles are routed to the milling department, avoiding the planers entirely.

The milling-machine table is a combination of milling and planing. It is rough milled all over and then planed top and bottom for finish as this proves to be somewhat cheaper than milling, because of the possibility of ganging in two rows, and we prefer a planed finish for the table top.

All the cases cited must meet exacting specifications. All go through a hand-finishing operation that demands accuracy from both the miller and planer because of the expense involved when too much must be finished by hand and surfaces are not flat and parallel.

We have learned that we can hand-finish just as cheaply with a milled surface as with a planed surface, and, in many cases, more cheaply. This is due to the nature of the casting, which lends itself better to milling than to planing, as it is well known that in planing under certain conditions the localized loads at the planer tool deflect the work, whereas a milling cutter, with an entirely different action of cutting and the fact that it covers a larger surface, does not have this effect.

It is only natural that, as manufacturers of milling machines, our minds should turn toward milling; but many of the milling machines we use for this class of work are of a type and size that we do not manufacture. Thus to our minds, milling, in many cases, will be found just as satisfactory and even more profitable than planing, if the proper planning and tooling are provided.

L. F. NENNINGER THINKS MILLING IS REPLACING PLANING

L. F. Nenninger[2] presented his ideas as follows:

Twenty or thirty years ago planing was considered the only good method of machining the surfaces on medium and large parts. At that time large milling machines were not

[1] Director of Design, Brown & Sharpe Mfg. Co., Providence, R. I.

[2] Cincinnati Milling Machine Co., Oakley, Ohio. Mem. A.S.M.E.

sufficiently developed to be considered a major competitor to planers.

Evolution and development have taken place in milling machines and the art of milling has been continuously spreading to new fields so that, quite naturally, the machines have been changed and redesigned to fit new requirements.

Large and medium-sized milling machines have adopted the time-saving and utility features so valuable in the smaller types of milling machines. Greater rigidity and more rugged cutting ability have been built into the machine and the tools, and today these machines represent a high state of development.

I do not wish to give the impression that planer development has been at a standstill through these years, but I do believe that there has been more progress in medium and large milling machines and their application to the job than there has in planers.

Today, in the shops of the company with which I am associated, planing has to a large degree been replaced by milling. This is not entirely because, as manufacturers of milling machines, we are naturally proponents of the milling method, but because we have found out that, in the majority of cases, milling is faster, better, and cheaper than planing. We still use planers and probably could not get along without them. We mill nothing that can be planed better or more economically. Generally speaking, long narrow surfaces can be more cheaply planed than milled, but the result is not necessarily better.

Surfaces can be machined just as accurately on a well-designed modern milling machine as on a first-class modern planer. In some cases, where surfaces to be machined are large and not rigidly supported to adjacent walls, milling has produced flatter and more accurate work than planing. This has nothing to do with the machines in question but is the result of the method of machining. In the case of the planer, localized loads at the tool deflected the work by a greater amount than in milling, in which case the tool loads were distributed over a larger area.

We have further noticed, particularly in the case of cast-iron parts, that the finished surface produced by a face milling cutter appears to be and is smoother than a planed surface. In many cases less hand work is necessary to finish the part to the desired degree of perfection.

Another advantage that milling has over planing is that there is considerably less breaking down of the edge at the end of the cut, particularly on cast parts. It is frequently necessary to slow down the operation on a planer to prevent excessive "breaking out" of the work at the end of the cut. This is seldom the case on a milling machine. In cutting steel, the problem of chips is greater with a planer than with a milling machine; the chips are smaller and more easily handled in the case of the latter.

On production jobs, where low cost is being strived for, it is possible to vary the feed rate of the cutter automatically as it progresses across an irregularly shaped workpiece.

For example, a casting may be generally narrow except at some one spot. With such a piece a planer would cut a lot of "wind." If a milling machine is equipped with an automatic variable feed, the rate of feed can be whatever is best for any cross-section of the work.

The utility of the milling machine has been questioned in favor of the planer, particularly on jobbing work. It is quite possible that tools can be more quickly changed on a planer, but that is only a small part of the story, as the set-up time on medium and large parts is usually long. I can see little difference in the time required with the two types of machines in question. However, it is possible to do more machine work per set-up of the work piece on a milling machine than on a planer. Such operations as boring, drilling, spot facing, etc., are frequently performed with the same set-up of the workpiece. This flexibility is indeed a real time and money saver.

Small tool and jobbing shops are fast replacing their planing and shaping machines in favor of the more flexible milling machines.

Each user has his own problems before him. No two have the same. Careful consideration of the facts alone will dictate the best and most economical method to use. My impression is that the future will find more users changing over to the milling method.

COLEMAN SELLERS, 3D, FINDS THAT EXPERTS DISAGREE

Coleman Sellers, 3d,[3] said:

These three papers cover the subject quite thoroughly. The authors are to be complimented on their broad-minded consideration of the subject. It is quite evident that there is much to be said on both sides.

Mr. Cardullo says that milled bearing surfaces, subsequently hand scraped, are inferior to planed surfaces unscraped. Mr. Harrison states that a milled surface can be scraped to an acceptable finish in approximately half the time required to do the same work when the slide has been planed, and that the finish produced by the milling machine permits an unscraped surface to assume an 85-per-cent bearing in about half the time required for a planed surface under the same conditions.

Mr. Cardullo and Mr. Harrison evidently do not agree in the question of finish. In the question of appearance, is it not a matter of opinion as to whether the circular milling feed marks are preferable to the straight lines of the planer finish?

Another point of disagreement seems to be in the matter of rate of removal of metal. One says, "The planer can remove metal faster than any other type of tool." The other says, "There is no difference in metal removal rate." We believe that it depends entirely upon the work and the tool. Numerous examples could be quoted to show that sometimes planers and sometimes milling machines can remove the metal faster. In general, with an efficient milling machine and with work on which the cut can be continuous, the milling machine will remove a greater amount of metal as no time is lost on the return stroke.

One of the authors has stated that on cast iron the planer tool opens the pores more than the milling cutter. This is perhaps true, but most bearing surfaces are now made of iron or semi-steel which is so close-grained that the difference in porosity is negligible.

The same author states that the finish on a planer suffers from poor hand grinding of the tools. Shops doing first-class work should have grinding machines for their tools so that this objection should not count. At any rate, it is not fair to consider that milling cutters are accurately ground and that planer tools are ground by hand by each planer operator. Both types of tools should be considered on the same basis.

Mr. Danekind states that "present-day planers, do not differ from those of twenty years ago except for greater rigidity." This is an exaggeration, as all planer builders will no doubt agree. The modern planer has many features, such as power traverse, micrometer dials, power-operated clamps, higher speeds, duplex control, improved tool lifters, etc., which improve its usefulness and cut down the set-up and cutting times.

Mr. Harrison has stated that it is commonly accepted practise to rough and finish with the same cutter and increase the

[3] William Sellers & Co., Inc., Philadelphia, Pa. Mem. A.S.M.E.

speed of rotation for finishing. It is our experience and that of a number of others that the feed and not the speed of rotation should be increased for a light finishing cut.

It is hoped that the presentation of both sides of this problem will help to straighten out in the minds of some of us the relative merits of these two types of machines.

F. E. CARDULLO TAKES ISSUE WITH MESSRS. DANEKIND AND HARRISON

F. E. Cardullo took issue with his fellow contributors, as follows:

Contrary to Mr. Danekind's impression, planers are susceptible to a high degree of specialization for a wide variety of work, and have been developed greatly in convenience and ease of operation, in late years. The development of the milling machine is not due to any basic change of design but rather to improvement in tool steels, and the planer shares equally with the milling machine in this improvement.

Designers may specify scant finishes, but depths of cut varying from three-eighths of an inch to more than one inch are common in large castings and forgings. During the past month we have planed castings having a $1^1/_8$-in. depth of finish. Such a finish is common when rough patterns are used.

Milling-machine bearing surfaces are milled for advertising reasons only, and such machines are used only for ordinary commercial work where accuracy is not required. The highest grades of milling machines have planed or ground bearing surfaces.

In pieces approximately 4 ft square, high-class milled work has errors approximately four times as great as high-class planed work. This may or may not be an objection to the use of the milling machine, depending upon the permissible tolerances. Sound engineering never demands unreasonable accuracy.

Mr. Danekind errs in assuming that the destruction of the edge of one or more milling bits is unimportant. Such an accident doubles or trebles the chip load on the following bits. If the chip load is light, this makes no difference until the cutter must be ground, at which time all the bits must be ground away until the imperfect bit is fully corrected. This involves extremely high grinding cost. On the other hand, if the chip load is heavy the cutter is quickly ruined and must be replaced.

Mr. Harrison considers the economics of milling solely from the standpoint of the cost of machining certain surfaces on a piece of work. This is not the proper economic analysis of the problem. He should consider the cost of performing not one operation, but a series of operations including the assembling and erection of the machine of which the piece forms a part. It is perfectly possible to save a great deal of time and money in machining certain surfaces on a piece, and subsequently to expend a great deal more time and money in correcting the errors which the method of machining introduced. What we wish to discover by our analysis is that series of operations which gives us our finished product for the least total cost, irrespective of the cost of a particular machine operation. The correct method of considering the matter is to consider both the cost and the value of the completed machine. Sometimes the value of a machine is independent of the method of machining. For instance, we mill the top of a cylinder block and the cylinder head of an automobile engine, and we would not increase the value of the engine in the least if we planed, ground, scraped, or lapped these two surfaces, for the reason that a thick gasket of copper and asbestos is placed between them which fills the imperfections left by the milling cutters. However, when we wish to fit the two halves of a steam-turbine casing, we plane the job, as Mr. Danekind points out. Milling would be cheaper, but the product would be valueless.

In breaking down the items affecting the cost of an operation on a piece, I believe Mr. Harrison has made two errors. In the first place, the method of allocating the burden used in the particular plant has no effect on the real cost of the operation. If an incorrect method of allocating the burden is used, the man who analyzes the cost figures is only "kidding" himself. In the second place, machine tools cannot be maintained at 100 per cent productivity. If we could maintain tools at 100 per cent productivity, we would have no depressions. With a given quantity of work to be done, a highly efficient machine may be operated only part of the time.

While fixture development for milling machines has reached a much higher level of efficiency than for planers, this is true only in the case of mass production. There is no reason why planer fixtures of general utility cannot be developed, and they are developed whenever the management is intelligent enough to appreciate their usefulness.

Neither is there any reason why a planer provided with duplex tables takes up any more shop room than a milling machine on the table of which one piece can be loaded while another is machined. If one piece six-feet long is to be loaded while another is machined, a twelve-foot table is required on a milling machine, and two six-foot duplex tables are required on a planer. The planer has the advantage in that the work is loaded or set up on a table which stands still, while in the case of a milling machine it must be set up on a moving table.

Mr. Harrison speaks of the milling machine as being more versatile than the planer, while Mr. Danekind and myself maintain that the planer is more versatile than the milling machine. Mr. Harrison has in mind a milling machine provided with all conceivable types and kinds of cutters and attachments, and such a machine, while not able to do all that the planer can do, can be used for drilling and boring in addition to milling. Mr. Danekind and myself had in mind the ordinary shop where such an extraordinary variety of cutters and attachments is not available; in which case the planer can do all that the milling machine can do, except bore and drill. Planers can be and have been provided with slotting attachments, milling attachments, drilling attachments, and grinding attachments, but it is not usual to do so. Neither is it usual to make a "Christmas tree" of a milling machine in order to add to its versatility. If the owner is willing to spend time and money to equip a planer to do all sorts of jobs for which it is not particularly fitted, its versatility becomes truly remarkable. Mr. Harrison lacks imagination when he provides his milling machine with slotting and planing attachments and does not recognize the fact that planers have been provided with slotting and milling attachments and may readily use tool-post grinders, air drills, and such other equipment as is desirable or necessary in doing any sort of work.

In the matter of accuracy, I am obliged to differ with Mr. Harrison. There are no accepted limits of accuracy and tolerances common to the machine-tool trade. Each manufacturer makes his own limits to fit a peculiar field. In no field are the limits of accuracy more exacting than in the planer field. With equally accurate guides, the accuracy of finish produced by a generating cut depends upon the relation between the rigidity of the structure and the weight of the moving parts. The weight of a moving planer head is much less than that of a moving milling head, and consequently the deflection of the structure is less. Nor does the milling machine generate the surface which it finishes; it reproduces all the errors made in grinding cutters to form, together with errors

due to run out of spindle or arbor, and misalignment of spindle. It follows that with equal classes of workmanship, the planer will produce the more accurate job. In the matter of a good commercial finish on machined surfaces, the milling machine is superior in one case only, namely, when slab milling with a coolant on steel. Most milling that competes with planing is not slab milling, but face milling, and the planer tool produces a far better finish than that produced by a face mill. If a superior finish is required on any material, soft steel included, the planer can produce a finish equal to good commercial grinding.

I have never known castings to be rejected because of porosity due to the method of machining. Either the castings are dense, or they are porous. No method of machining will make a porous casting more dense, or a dense casting more porous. In this connection, it may be pointed out that the roughness of a machined surface depends on the depth of the cut, and the effective depth of a roughing cut depends on the curve to which the lip of the tool is ground. A planer finishing tool taking a light scraping cut at the proper speed leaves a casting with a much smoother finish than does a milling cutter. To be sure, a dull milling cutter taking a very light cut may act as a burnishing tool, but such a surface, while bright and smooth to the eye, is not true and is useless for the purpose of machine construction.

Many plants provide inadequate facilities for grinding planer tools, and have not standardized on proper forms for such tools. This, however, is the fault of the plant, not the planer. When provided with an adequate supply of properly ground tools, great savings may be made in the cutting time, and much better planer work may be turned out. With poorly ground tools, the planer will produce fair work, so production-engineering departments often neglect such tools. In order to secure satisfactory milling, it is necessary to go to considerable expense in purchasing a great variety of cutters, to provide accurate cutter grinders and grinding fixtures, and to secure skilful and experienced tool-room labor. It would seem that the very fact that high-grade tool-room procedure is necessary to produce decent milling, while ordinary hand grinding produces equally good or even better planing, is an argument in favor of the planer as a finishing tool.

With regard to the amount of hand correction necessary after planing and after milling, I again disagree with Mr. Harrison. No hand correction is required after a job is properly planed. Mr. Harrison admits that hand correction *is* necessary to produce an acceptable finish on a milled job. The reason that planed work usually requires hand correction is because planing is the first operation performed on the piece, and the succeeding operations, such as drilling, boring, tapping, and keywaying, distort the planed surfaces. If planing is the last operation performed on the piece, and the planing is properly performed, no hand correction whatever is necessary, and any attempt at hand correction will only serve to destroy the truth and accuracy of the planed work.

Mr. Harrison states that a milled surface permits a loaded slide which has not been scraped to assume an 85-per-cent bearing in about one-half the time required by a planed slide under similar conditions. I do not know what the conditions are. I can only point out that a properly planed table and bed for a planer or milling machine will in the beginning have a 100-per-cent bearing without any hand correction whatever. Mr. Harrison is correct in stating that true planes are necessary for satisfactory bearing surfaces and since the planer is the one machine best capable of producing a true plane, it follows that the planer is the best machine for producing flat bearing surfaces.

Mr. Harrison is in error in claiming that the "rotary coverage" of the milling cutter is generating in its action. The milling cutter depends on the copying principle. In other words, if the cutter acts in the manner intended, the machined surface is an exact copy of the cutters used. On the other hand, the planer is *not* a copying machine, but a generating machine. No matter what the error of the tool may be, the repeated strokes of the planer, as the tool is gradually fed over, produce a flat surface, and if the tool is properly set and the edge is a straight line parallel with the movement of the tool, the generated surface will be absolutely flat.

Machinability does not depend primarily on the type of machine used for doing the work, but upon the strength, toughness, and hardness of the tool which does the work. Planer tools are, alas, too frequently heat treated by a blacksmith who judges the heat by his eye. Milling cutters, on the other hand, are usually heat treated in lots by competent manufacturers who use the best equipment available. Consequently, the ability of the steel in a milling cutter to cut hard and tough material *may* be superior to the ability of the steel in a planer tool to cut the same material. In the average case cutting speed may be increased 40 per cent by the substitution of scientific for rule-of-thumb heat treatment. If the planer tool has the same composition and heat treatment as the milling cutter, it is possible to grind it with more favorable lip and clearance angles and to cut harder and tougher materials with it than can be cut with a milling cutter.

A planer tool always cuts a chip of uniform cross-section. A milling tool cuts a chip of varying cross-section. Since a chip of given weight and of a cross-section varying from zero to a permissible maximum requires more power for its removal than does a chip of the same weight and permissible maximum cross-section, a milling machine always takes more power at the tool point than does a planer. Cubic inches removed per minute is no criterion by which to judge the efficiency of milling or planing, unless we know what metal is cut. While it is possible to mill 300 cu in. of aluminum or leaded brass per minute with 100 hp, no such rate of removal is possible in cast iron or steel.

Under certain conditions, the milling machine may waste less power in moving its parts than does the planer, so that sometimes the balance is in favor of one machine and sometimes of the other. In the case of large work and deep cuts, the balance is always in favor of the planer. It is possible to vary automatically the milling feed so that the motor will always be loaded to capacity, as the width of work milled or the depth of cut varies, but this is practical only when quantity production warrants the construction of the necessary cams to control the feed. In a planer, the feed is always under the control of the operator and, when desirable, we may resort to short-stroking some parts of the work and long-stroking other parts. In practise, the planer can operate to the same advantage as the milling machine in removing metal of variable depth of cut and width of surface.

Mr. Harrison uses the equation, "First cost plus maintenance cost, divided by the total number of units produced over a period of years, equals unit cost." To the first cost plus maintenance cost I would add the production engineering cost, the tool cost, the tool-grinding cost, the cost of correction, that part of the cost of assembling or erecting due to imperfections, and any loss of value of the product due to the method of machining employed.

The figures presented on the length of life of milling cutters and the amount of material removed for each cent invested in high-speed steel are interesting. However, no mention is made of the fact that these cutters were reground much

more often than is customary, apparently with the idea of reducing the cost of tool steel. If to this extreme low cost of tool steel we add the extra cost of changing and of grinding the cutters so frequently, it will be found that the cost of machining the parts was actually increased by the frequent grindings.

In this connection, it may be pointed out that the milling machine, unlike the planer, always involves a high tool-room cost for keeping the cutters in order. This cost is not usually charged to the milling machine, but is allocated against all of the tools, including the planers, making the cost of milling appear lower than it actually is, and the cost of planing appear higher than it actually is. In addition, since the planer tools often do not go to the tool room to be ground, but are ground by planer operators, the time of grinding planer tools is then charged directly against the planer itself, so that under many cost systems and tool-room procedures, the planer is severely and unfairly penalized by the cost of maintenance of milling-machine cutters.

R. E. W. HARRISON ANSWERS MR. CARDULLO

R. E. W. Harrison, reviewing the entire discussion, prepared the following closure to it:

As was intended, the symposium has produced a lively discussion of the relative merits of milling and planing as machine-shop processes and as is not infrequently the case the discussion rivals the papers in bringing out important facts. It would seem, however, that Mr. Cardullo's penchant for the planer has led him to make a number of statements which are largely matters of opinion. Taking the various points in the order in which they are raised:

It is agreed that there is no basic change of design, but to attribute the birth of the milling machine to improvement in tool steels is, in the writer's opinion, inaccurate, as milling machines were in use long before the introduction of high-speed steel; and even today the cutter manufacturers sell a great many carbon-steel milling cutters—in some instances and countries 40 per cent of the total number sold are of carbon steel.

To say that surfaces are milled for advertising reasons only is beside the point in this competitive age. The statement that the highest grades of milling machines have only grooved and planed surfaces is contrary to the writer's experience as an engineer employed by three of the largest machine-tool manufacturers in the world. Some have, it is true, but there are others equally accurate and well finished which are milled.

It is customary to use inserted-blade cutters for all high-production heavy-duty milling operations, and all such cutters are made so that if one or two blades are broken, they can be reset or replaced so that all that is necessary to bring the cutter back to 100-per-cent operation is to regrind the new blades and touch up the others to insure even cutting.

The writer agrees with the statement that the breakdown of cost elements is not as complete as it might be due to space and time limitations, but to throw the blame for lack of appreciation of the merits of planing on to the alleged deficiency in intelligence among users' managements is to court disaster, because, in the last analysis, these users are the judges of the accuracy of the work produced.

The writer has had user experience with both types of machines under discussion and unhesitatingly confirms the statement that there is nothing to choose between in the accuracy-producing qualities of both types of machines, a fact which is borne out by the willingness of the milling-machine makers to guarantee this accuracy when the work demands it.

On the subject of finish the debate can be readily removed from the realms of opinion by referring competing surfaces to the profilograph, the instrument being operated by a neutral party, unknown to either side. Some interesting results have been obtained with this instrument.

To censure the user for failure to provide proper grinding facilities for the planer tool is again a rather doubtful practise, inasmuch as the milling-cutter grinder is not an inexpensive tool, yet there has been no unwillingness on the part of users to install such facilities.

The figures quoted by the writer were factual, based on actual tests, and can be duplicated, if necessary, to substantiate the case. Furthermore, just as there are planers in use with non-hand-corrected surfaces, so there are milling machines, and both types of machines are producing work within equal tolerances, i.e., machine-tool and printing-machine slide ways, both calling for first-class work. It is a statement of fact that if the work is properly done, that is, if the operating technique is correct, both planed and milled surfaces do not require hand correction for the majority of requirements. The difference is in the time required to produce these accurate results.

The 85-per-cent bearing, referred to in the writer's paper is everyday practise in the works of one large manufacturer, this result being obtained by milling uncorrected by scraping. What Mr. Cardullo means by a 100-per-cent bearing, the writer is in doubt, as his research into surface qualities indicates that the 100-per-cent bearing is a Utopian ideal never yet reached in this imperfect world. The facts of the matter as borne out by the writer's detailed experience are that both the planer and the milling machine will produce acceptable surfaces with areas in contact sufficient to meet the most exacting requirements, without hand correction; but there are two points of difference: (1) Time required to produce this result. (2) When in those few cases where a scraped surface is necessary the actual measurements of metal removed by the scraper show that the average planed surface must be scraped to more than twice the depth of the milled surface to produce a scraped finish of equal merit. These figures again are the result of an actual test conducted while the paper was being prepared.

The writer would not propose to debate the question of generative action, except to say that in his own lack of an adequate dictionary definition he was encouraged to think that the rotary coverage of a milling cutter resembled the rotary coverage of a hob or the circular cutter of the modern bevel-gear machine, and in both these instances the makers have, for years, been offering them as gear generators, as distinct from the former gear-planer title.

In discussing machinability Mr. Cardullo again excuses the handicap of the planer tool's shortcomings by heaping coals of fire on the poor blacksmith, another case of the user's lack of appreciation. Is not the answer in the multiplicity of small cuts in rapid succession which is characteristic of a milling operation? The writer calls to mind an emergency job on some die shanks. One was routed to a planer and one to a planer miller. Tool-maintenance facilities were equal in the shop. The milling machine finished one while the planer operator replaced several broken tools and then took over the other because it was unmachinable on the planer. Here is an example of the superiority of the nibbling cut as against the slashing cut of the planer on a job of hard steel.

It is agreed that much has been done to facilitate the efficient employment of both types of machines, and while undoubtedly the speed and feed controls which have been evolved are the best for each type of tool, the fact remains that for work of greatly varying area, depth of cut, and irregular and wide spacing of the surfaces in one plane, the milling machine has

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MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

The Tennessee Valley Experiment

AS A LEADING article in this month's issue is published a discussion of certain phases of the great undertaking, under Government auspices, in the Tennessee Valley. Comment on the article and on the TVA project would inevitably lead to a discussion of the philosophy of government, a subject upon which wide differences of opinion exist and which is not exclusively in the province of engineering. The article itself is presented so that readers may be informed by means of an exposition, prepared by two engineers connected with the project, both of whom are members of The American Society of Mechanical Engineers, of an experiment in regional planning under Government supervision and in cooperation with private industry, that not only has many features of interest to engineers but that may profoundly affect industrial life in this country.

It is too early to judge, perhaps even to estimate, the value and importance of the project. Quite the most hopeful factor, in the minds of many, is the presence on the job of Dr. Arthur H. Morgan, engineer and educator, whose sincerity and integrity are doubted by none. Even the most violent critics of the TVA on grounds of national policy and the theory of government will admit that the execution of the undertaking will be honestly and intelligently carried out by Dr. Morgan; and members of the A.S.M.E. will be particularly gratified that he has associated with his staff two such men as Professor Woolrich and Mr. Ferris.

Putting the Junior to Work

ONE of the encouraging features of the 1933 Annual Meeting of The American Society of Mechanical Engineers was a report, prepared by a group of junior members, analyzing their relationship to the Society and suggesting ways in which the membership of younger men could be made more valuable to them and, reciprocally, to the Society. That report is published in this issue. It tells what the Society can do for the junior member, and suggests activities for him that will strengthen his interest and increase his value and loyalty.

This is important, hopeful, and stimulating. Youth movements are in evidence everywhere throughout the world. In some countries, born of idleness, disillusionment, and desperation, they have reacted destructively to democratic and political institutions. Revolutions, bloody and otherwise, strong nationalist movements, serious concern with the less frivolous aspects of existence, so rare in eras of peace and prosperity, unreasoning attempts to seek liberalism by way of intolerance and idealism by becoming stark realists, and many other evidences of emotional and intellectual conflicts bear evidence of the ways and impatience of youth from which the world has always found itself, spiritually, at least, replenished. And neither this country nor its institutions will escape rejuvenation.

If we, in this country, have certain advantages of environmental conditions and progressive traditions and take heed of the situation because we can see what is happening elsewhere, we will hope to direct this powerful force into constructive channels. We will provide opportunities for youth to express itself in creative work on projects to which it can offer an intelligent allegiance. And bringing this right down to the problem that faces engineering professional societies today, we will encourage every attempt on the part of the younger men to take active and serious part in Society affairs.

Already, in several localities, as the report points out, juniors are creating their own professional discussions and activities within the parent society. Work originated and carried on by these younger men themselves is of the most rugged constitution and will stimulate the enthusiasm which initiated it. By such means the profession gains staunch adherents, convinced, by their own experience, of the value of cooperative effort. We cannot have too much of it.

1400 Mechanical Engineers

WHEN the commencement exercises shall have been completed this year in a hundred of the country's engineering schools there will be eligible for transfer to junior grade 1400 student members of The American Society of Mechanical Engineers.

Avoiding, for lack of time and space, a host of thoughts engendered by such a significant fact, may we stress one that concerns members of long standing? These 1400 young men have what the world sorely needs, enthusiasm, ambition, and ideals. They also have a considerable respect for the great body of professional engineers with whom they are planning to associate. It is an easy matter to go through the formalities incident to changing their membership status. But to absorb such a group, particularly in times when engineering jobs are scarce, is not easy. The responsibility rests with the older men who can do two things that will justify the decision that these younger men make in joining a professional society: First, they can give these younger men opportunities for self-development by working in and for the professional society. Second, they can help these men prepare themselves to become members of the profession in their own right.

In The American Society of Mechanical Engineers, as noted in a report on the junior member, published this month, the first of these factors is discussed. The second is being studied not only by the Society in relation to its own problems, but by a Committee of the Engineer's

Council for Professional Development. Every engineer who has concern for the future of engineering should get behind both of these movements.

The Government Well Served

CASUAL observation at Washington confirms the belief that the Government in many of its recently acquired activities, is being served at extraordinarily low cost by men of high caliber. For not only are there men of outstanding ability giving their services in advisory capacities, but many of those doing the routine work of the numerous new agencies are hostages to fortune, serving at low wages because of the distressed condition of employment in industry and the professions. It is easy to see that much of the success in the stupendous tasks the Government has set for itself depends on the services of men who, in normal times, would be attracted neither by the salaries offered nor by the desire to work for the Government. Correspondingly, it may be argued that these men, as times improve, will find more attractive salaries and more congenial working conditions elsewhere, and there is likely to be left in what becomes permanent of our emergency agencies a residue of the least fit. If the Government hopes to retain the services of men of the caliber that are most useful to industry, it will have to bid for them. If it does not, incompetence is likely to clog the working of any permanent bureaucratic group attempting to guide industry.

Marine Boiler Rules

THE first report of a Committee to Coordinate Marine Boiler Rules on its work extending over a period of about two years, done under the auspices of the Bureau of Navigation and Steamboat Inspection of the Department of Commerce, has recently been issued. It covers two rules, the first dealing with material requirements and comprising specifications for materials, and the second covering the design, construction, installation, inspection, and repair of boilers and other pressure vessels, piping, valves, fittings, and their appurtenances, and rules for fusion welding and repairs.

The paramount objective has been to produce a code which would be comprehensive and broad enough to include all types of boilers in marine service under the provisions of which boilers constructed of better material in accordance with better design, and infinitely safer could be produced at a reasonable cost. With this in mind, the standard specifications of the American Society for Testing Materials and The American Society of Mechanical Engineers were adopted, with slight modifications, to make them workable as inspection, rather than purchasers', specifications, and to eliminate the necessity of having to order material made to special specifications, which would greatly increase the cost to the purchaser. This feature of the revised rules works to the advantage of manufacturers and purchasers for the reason that stock material can be used, thus obviating unnecessary and expensive delays.

Inasmuch as the current boiler rules were in part written into statute law, it was necessary that Congress enact legislation amending certain statutes in order to permit the adoption of the new code. Therefore, a bill drafted by the Bureau to enable the Board of Supervising Inspectors to adopt this new code was introduced at the last session of Congress. It passed both houses unanimously and was signed by the President on June 13, 1933. Therefore, final action by the Board of Supervising Inspectors is all that is necessary to make these rules effective.

In view of the rapid strides made in the art of fusion welding coupled with the fact that such organizations as The American Society of Mechanical Engineers, the American Welding Society, and the United States Navy have sanctioned the use of boilers and pressure vessels made by means of fusion welding, it was decided to incorporate in the proposed rules a complete code to cover the construction of boilers and pressure vessels by this method. The code thus produced is based on the A.S.M.E. Code of Welded Boilers and Pressure Vessels.

The code represents an important step toward the unification of boiler rules in the United States.

The Library's Valuable Books

ATTENTION is frequently directed to the value of the Engineering Societies Library in New York. As a collection of the literature of engineering it is indeed a valuable and interesting library. Ideas of value with respect to an engineering library, however, are likely to be expressed in terms of usefulness, and in such a rapidly changing profession as engineering, an extensive collection of the most recent books and periodicals is both useful and valuable.

In another sense of the term "valuable," however, the Engineering Societies Library may claim some distinction. This is in its collection of rare books and manuscripts, some dating back to the fifteenth century. A recent appraisal of the library's collections, for fire-insurance purposes, set the value of the general collection of books and bibliographies at $344,125, and the value of rare books and manuscripts at $28,800. The most highly appraised item is Wright's "Certain Errors in Navigation," printed in London in 1599 and valued at $2500.

It takes money to maintain and administer a valuable reference library such as that housed in the Engineering Societies Building in New York. The collection of books and the facilities of the library service are open to all engineers. In times of depression, adequate funds are hard to get but none the less needed. No member of any of the engineering societies contributing to the support of the library need begrudge the small fraction of his dues that goes to this joint undertaking. Any patron of the profession, or of libraries, who can make donations to worthy causes will find one in the Engineering Societies Library.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Thurston Wing-Tip Rotors Control Beyond the Stall

IT IS here demonstrated that a moving body or rider plane can generally be associated with a fixed body or plane for altering the aerodynamical properties of the combination and in particular that rotating cambered rider planes, when associated with the front edge of a fixed wing of standard section, are advantageous in improving the gliding conditions. By increasing the size of the rotors relatively to the size of the wings, this advantage is increased.

The report further demonstrates that such rotors may be used for controlling the machine laterally, directionally, and longitudinally, in addition to stabilizing it. In other words, rotors may be used instead of, or in addition to, ailerons, rudders, and elevators, and thus may be associated with the trailing edges of a fixed wing for various purposes. It is even claimed that blades or riders if rotated about an external axis to sweep out "surfaces of revolution" may be used for reducing the head resistance and increasing the cooling of air-cooled engines mounted in the nose of an airplane body or the like. The methods of carrying the rotors are briefly explained in the original article.

The author has made rotors which automatically open and close according to the inclination of the main plane. If it is only desired to use the rotors for landing or to get a machine out of a spin, there is no need to make rotors automatically closing, as this can be done after the machine is landed. The author has also been successful in constructing rotors which would form "living" biplane or triplane slots while in rotation, and he has constructed riders which would trail in the wind like a streamer flag until it was desired to bring them into rotation to form "living" slots or parachutes. (Report No. BA 1083 of the Royal Aircraft Establishment, with introduction by A. P. Thurston, abstracted through *The Journal of the Royal Aeronautical Society*, vol. 38, no. 278, February, 1934, pp. 138–140, *e*. See also A. S. Hartshorn and C. Callen, same report, same issue of *The Journal of the Royal Aeronautical Society*, pp. 141–161, illustrated; in particular, tables of lift results and compound lift and drag results, pp. 155–161, *eA*)

APPLIED MECHANICS

Factors Affecting the Grip in Force, Shrink, and Expansion Fits

THE development of high-speed machinery has created a set of conditions in the hollow element involving a shaft which could not be met successfully by the use of keys and keyways. A tendency for the wheel to become loose in the solid element due to the increase in the size of the bore under centrifugal action could, in the view of the author, only be successfully prevented by an assembly which induced in the material surrounding the bore elastic strains and stresses in excess of those to which the wheel would be subjected at the maximum speed of rotation. Such an assembly required the free diameter of the solid element to be slightly larger than the free diameter of the hollow element. Information is required which would lead to standardization of the procedure of making such assemblies. The failure of the early turbine disks to maintain their grip through the reduction of the interface pressure to zero, the loosening of the drums on shafts due to temperature effects, etc., had all resulted in a technique of a higher order in making the fit assembly. Workshop practise today is, however, quite varied. The nature of the finish of the surface differs broadly and fit allowances appear to vary within wide limits. For example, a certain shrink-fit assembly had fit allowances ranging between 0.001 and 0.00175 in. per inch diameter for the same quality of material, and the results appear to be equally successful, despite the fact that at the higher fit allowances, the stress induced in the bore layers was well above the elastic limit of the material. The author refers to the use of Lamé's thick-cylinder theory to determine the magnitude of the stresses induced in the two elements.

A study of load-extension diagrams would suggest that the maximum radial interface pressure between the elements would be attained with a fit allowance that resulted in yield conditions at the inner bore layers. (Russell and Shannon, *Journal*, Royal Technical College, Glasgow, 1930, Vol. 2, p. 250.) Excessive fit allowances were often used, and under such conditions a plastic or semi-plastic range might penetrate well into the wall thickness of the hollow element and result in an almost complete destruction of the compressive elastic properties of the material. The layers within the permanently deformed range would be subjected to a compressive stress exerted by the outer layers, which were in tension within the elastic range of the wall thickness. The magnitude of the radial interface pressure could not be accurately determined if the elements were mated under such conditions. Overstraining in this manner, if followed by a mild heat treatment, would improve the elastic properties of the hollow element and result in a more uniform distribution of stress throughout the wall thickness. This would allow of a greater interface pressure between the elements of an assembly or an increase in the permissible bore pressure in gun construction.

The author refers to a case of application of force fits to an assembly of wheel centers on axles for a British standard 12-ton ore car. He shows why the assembly failed by being apparently made under plastic-flow conditions which penetrated well into the wall thickness of the wheel boss and led to a condition of permanent set. He also tells of tests carried out with a pin and collar having a force-fit allowance of 0.006 in. with a plain internal surface for the collar, as well as with grooves of different dimensions cut on it.

The load diagrams obtained clearly indicated that a reduction of area created by bearing-band surface conditions on the surface of one of the mating elements resulted in a big reduction in the maximum load at which axial slip occurred in assembly units. An out-of-straightness condition of the cylindrical surface of an element might result in a series of bearing bands approaching any of the conditions used in the tests. The dimensions of the mating surfaces measured throughout the tests showed no signs of change. This was remarkable, in view of the fact that the elements were as-

sembled and dismantled five times. Inspection of the narrow bearing strips gave evidence of good bearing conditions, with no signs of damage due to shear in the assembly operation, despite the fact that the force-fit allowance of 0.006 in. induced an interface radial pressure intensity of 2 tons per sq in. There was evidence to show that the degree of smoothness of the surfaces resulting from different machining operations had practically no effect on the coefficient of friction and the force necessary to bring about slip. Good modern machine-shop practise gave a degree of finish to mating surfaces more or less free from tool ridges. Many such surfaces had, however, a pronounced out-of-straightness defect. For this reason it was suggested that for elastic-grip assemblies greater attention should be given to the need for a higher degree of accuracy in the generation of the surfaces, a condition more difficult to attain than a high surface finish, but one that would be facilitated by the final metal-removal operation by grinding.

The influence of the lubricant used in a force-fit assembly on the pressing-on load was next considered and some very carefully conducted tests were made. The values of the pressing-on loads showed a remarkable influence exerted by the film of lubricant. The values ranged from 5.1 tons with rape oil to 13.55 tons with Bayonne oil. The intermediate values were sperm oil 5.35, Texaco 9.60, graphite and engine-bearing oil 6.40, and a cutting lubricant 5.94 tons. It had come to be recognized that these lubricating films were really in chemical union with the mating surfaces of the elements. The molecules orient themselves on the solid surfaces and form an adsorbed primary film. There was evidence that by gentle treatment with a clean cloth the lubricant could be polished off the surfaces and its influence lost, and further, that this effect could not be produced by the force-fit assembly process; the primary films, even under high radial-pressure intensities, seemed to exercise an enormous influence on the load necessary to produce slip.

Tests were also made to find the quality of the grip established by such assembly methods, as well as on expansion fits made by using liquid oxygen.

The conclusion to which the author comes is that the degree of accuracy in machining the mating surfaces of an elastic-grip assembly was of more importance than the nature of the finish. All materials used in such assemblies should be specified by their elastic properties and test pieces should be taken from where the material was weakest. British railway practise in selecting the web of a wheel center is unsatisfactory and fails to provide reliable data. A successful shrinkage assembly could be established with a fit allowance producing stresses well within the elastic range of the material, if the mating surfaces were perfectly dry and free from film. No evidence was found that "the torsional coefficient of friction is greatly in excess of the axial coefficient of friction." Because of lack of space the discussion cannot be reported here. (H. L. Guy, paper read at the meeting of the Northwestern Branch of the Institution of Mechanical Engineers, in Manchester, Dec. 7, 1933, abstracted through *Engineering*, vol. 136, no. 3546, Dec. 29, 1933, pp. 706–708, *epA*)

ENGINEERING MATERIALS

Acetamide as a Solvent

THIS material, an amide of acetic acid, is said to possess quite unique characteristics. It combines with acids and yet partakes in part of both acid and basic characteristics, being itself neutral in reaction.

Since acetamide is fairly soluble in its own weight of water and possesses definite hygroscopic properties, it is expected to prove a good moistening agent, keeping glue, gelatine, leather, cloth, and various films and coatings soft and pliant.

Kauffman indicated its possibilities as an activator in textile bleaching and it may be expected to work as a water-soluble penetrating agent. There are several patents outstanding covering different applications of acetamide. Among other things it has already been employed in soldering-flux combinations. The main properties of the material are listed in the original article. (S. J. Cohen, President, American Chemical Products Company, in *Chemical Industries*, vol. 34, no. 2, Feb., 1934, p. 109, *d*)

FUELS AND FIRING

Combustion in Boilers

THE author, a professor of power-plant engineering, heating, and ventilation at the Technical High School in Hannover, in reporting the research done at his institution, points out that in the past there was an inclination to consider the processes of combustion as exclusively chemical or physical. He believes, however, that this process belongs to a great extent to the province of rheology and that it is necessary to abandon completely the old method of static consideration and look at the phenomena of combustion dynamically. Notwithstanding the paucity of available means for this kind of investigation, the author made an attempt to penetrate into this domain of dynamics and presents in the present article some of the data obtained by him and his collaborators beginning with the theoretical fundamentals of the combustion processes. Fig. 1 is a diagram from which it is possible to read off at once the theoretical temperature of combustion of a fuel at various degrees of preheat of air, and to determine directly for a given measured temperature of the combustion chamber how much of the heat value contained in the fuel is given up to the heating surface by radiation. It was necessary to create the concept of "average temperature of the combustion chamber" in order to perform the necessary calculations. It does not exactly correspond to practical actuality as the temperature in a combustion chamber is really quite variable. Thus, for example, the method of generation of radiation due to the variably occurring processes of combustion at different places on the grate may affect quite powerfully the local temperature. In order to judge processes of combustion one must first form a clear idea as to self-ignition and the explosion range of the important gases. The ignition point of the gases generated from the fuel constituents is the higher the simpler the gases are. Thus, for example, methane ignites at about 700 C (1292 F) and has an extremely narrow range of explosibility (*Die Wärme*, Vol. 53, 1930, p. 714, article by the present author).

Fig. 2 shows that the velocity of ignition is greatest with the hydrogen and least with carbon monoxide and methane. This, and the circumstance that the velocity of ignition increases with the square of the absolute temperature, would indicate how important a highly heated roof is for ignition. Furthermore, the catalytic influence of water vapor must be taken into consideration, as entirely dry carbon monoxide has much poorer ignition characteristics than humid carbon monoxide. The fluid constituents present in fuel show widely different contents of hydrogen. Because of this, lean coals ignite with the greatest difficulty, this being due to the lack in them of easily ignitible heavy-molecule hydrogen compounds. On the other hand, Fig. 3 shows a diagram of the combustion process of rich coals on a traveling grate, drawn by Werkmeister and taken from his thesis presented to the

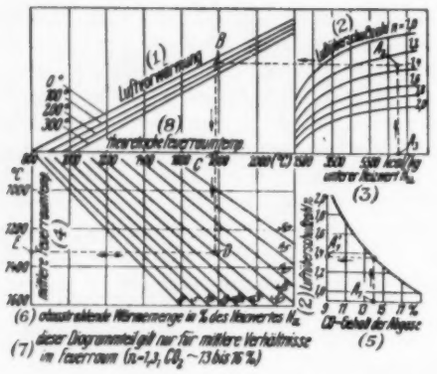


FIG. 1 DETERMINATION OF THEORETICAL AND AVERAGE COMBUSTION-CHAMBER TEMPERATURES FROM THE HEATING VALUE OF THE FUEL, COEFFICIENT OF EXCESS OF AIR, EXTENT OF AIR PREHEATING, AND AMOUNT OF HEAT RADIATED

(1 = Air preheating; 2 = coefficient of excess of air; 3 = lower heating value H_u in kcal per kg (1 kcal per kg = 1.80 Btu per lb); 4 = average combustion-chamber temperature; 5 = content of CO in exhaust gases; 6 = amount of heat radiated in percentages of heat content H_u; 7 = this part of the diagram is valid only for average conditions in the combustion chamber, namely, $n = 1.3$; CO_2 from 13 to 16 per cent; 8 = theoretical combustion-chamber temperature.)

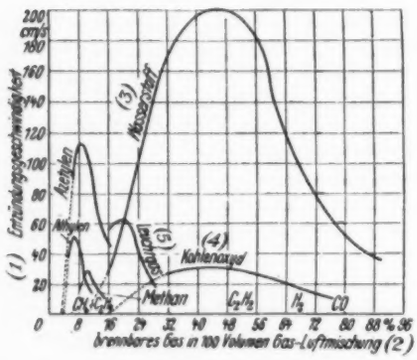


FIG. 2 VELOCITY OF IGNITION OF VARIOUS GASES

(1 = Velocity of ignition; 2 = combustible gas in 100 volumes of gas-air mixture; 3 = hydrogen; 4 = carbon monoxide; 5 = illuminating gas.)

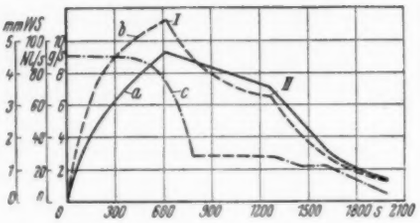


FIG. 3 COMBUSTION OF RICH COALS

(From tests by Werkmeister; ordinates in mm of water.)

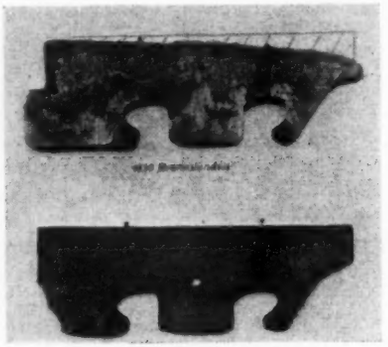


FIG. 4 GRATE BAR NEW (BELOW) AND AFTER 1850 HR OF OPERATION (ABOVE)

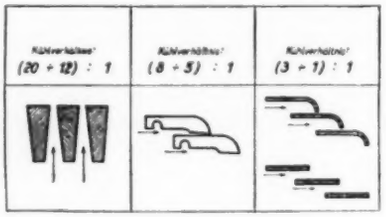


FIG. 5 GRATE-BAR SHAPES

(Kühlverhältnis = cooling ratio.)

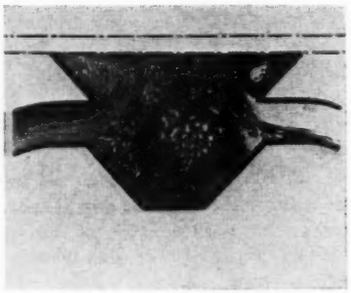


FIG. 8 COMBUSTION IN ONE ZONE OF A MODEL OF A FORCED-DRAFT TRAVELING GRATE

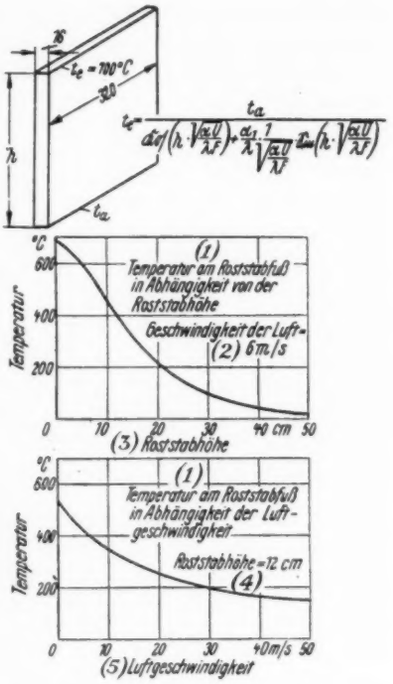


FIG. 6 TEMPERATURE OF GRATE BARS

(1 = Temperature at the foot of the grate bar as determined by the height of the grate bar; 2 = velocity of air, 6 m per sec (19.68 ft per sec); 3 = height of grate bar; 4 = height of grate bar, 12 cm (4.72 in.); 5 = velocity of air.)

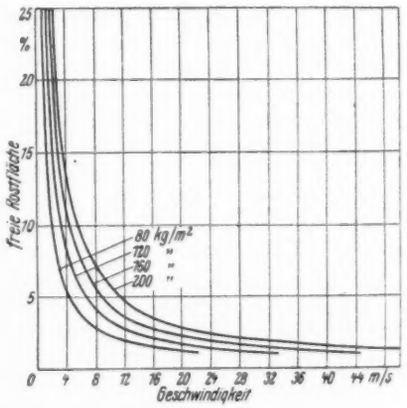


FIG. 7 AIR VELOCITIES IN THE GRATE

(Ordinates, free grate areas; abscissas, velocities.)

Technical High School in Hannover in 1932. This curve shows that the combustibility of coal rises fairly rapidly up to a peak and then falls off because of lack of air and does not begin to run the "right" way until after it has passed point II. These theoretical considerations offer material information for the design of vital elements of a grate. Fig. 4 shows a grate bar as it was when first installed and as it was after 1850 hr of operation. It will be noted that at one place where this grate bar was poorly cooled, it has been quite burned away. Fig. 5 shows the proper ways of cooling for various kinds of grate bars. The lower the temperature of combustion, which means the lower the heat value, the less need be the cooling ratio. The importance of maintaining the grate bars in operating conditions led to undertaking a careful analytical and experimental investigation of the problem of cooling the grate bars. Fig. 6 shows the temperature variations in a grate bar operated with a given air velocity. Fig. 7 shows the air velocities with various free grate areas. Since the cooling itself is affected by the velocity, the free grate area in turn affects the cooling ratio. The experimental investigation of this problem has not yet been completed. Engr. Bock, a collaborator of the author, is just now engaged in passing an air blast over grate bars made of ice in order to obtain an insight into the conduct of temperatures in a grate. The distribution of the air of combustion in a grate is of fundamental importance. Fig. 8 shows a test on a model of a zone of a "forced" draft traveling grate.

It will be observed that only a fraction, say, 60 to 65 per cent, of the path of combustion affects that zone. On the edges turbulence takes place, so that the process of combustion occurs in an irregular manner.

Fig. 9 in the original article (which cannot be reproduced for technical reasons) shows from a test on a model the flow process in a combustion chamber equipped with a traveling grate. From this it would appear that the gas streams originating in various zones flow side by side without mixing. This brings us to another important fact dealing with the process of combustion and that is that the various gas streams leaving the furnace flow side by side without mixing, and it may happen, therefore, that the data on carbon dioxide as well as the picture of temperature and velocity changes in a boiler or furnace may exhibit extraordinarily great variations and the methods hitherto employed for measuring temperatures may lead to extremely misleading results.

It is only by investigating all these problems and reliably determining what factors affect processes of flow that it will be possible to find the proper constructive methods for designing furnaces. The author then proceeds to the consideration of processes of flow in a boiler and to the dynamics of treating boiler feedwater. This part is not suitable for abstracting. (Prof. Macard, Technical High School in Hannover, in *Archiv für Wärmewirtschaft und Dampfkesselwesen*, vol. 14, no. 10, October, 1933, pp. 262–264, 13 figs., *etA*)

The Combustion of Pulverized Fuel

ONLY the high lights of this interesting article can be abstracted. To attain maximum load, it is only necessary to grind the fuel to a limited degree of fineness, any further reduction in size showing much less influence on the combustion time. It is the present author's contention that one of the primary problems of the combustion of coal dust is to be able to burn material larger in size than that now allowable, say, between 0.25 mm (0.00984 in.) and 1 mm (0.03937 in.). A burner now being developed by the Fuel Research Board appears likely to assist in achieving this object.

To understand the nature of the influence exerted by the coal during the combustion process, it is necessary to consider the behavior of different coals when heated. During the temperature range from 0 to 350 C (32 to 662 F), the coal evolves chiefly oxides or carbon and some water vapor, these gases being more of a hindrance than a help to the combustion process. It appears, therefore, to be incorrect practise to allow this stage to occur in the furnace and it would appear that the pulverized coal should theoretically be heated to 350 C (662 F) before being fed into the furnace. It is at temperatures above 350 C that coals differ so greatly in properties, one from another, these differences depending primarily on whether the coals are coking or non-coking. The processes in both cases are discussed in detail in the original article.

The conclusion to which the author comes is that coal used for pulverized-fuel firing should be examined microscopically and that coals should be selected that are rich in plant remains. It may ultimately be accepted that only such coals and the non-coking coals will be selected for coal-dust firing.

The combustion of a particle in the furnace depends upon two consecutively acting factors. One of these is the rapidity with which the particles of coal are heated to their ignition temperature, and the other the rate with which oxygen can be brought into contact with the carbon residue remaining in the particles after the gases have been largely distilled away. If cold air and cold coal are charged into the furnace, it is clear that an appreciable, but quite incalculable, time will be occupied in raising the temperature to that of ignition. If, however, the air is preheated so that the particles of coal during the first fraction of a second of their travel in the furnace meet such conditions that their surface temperature is raised to 500 C (to take an arbitrary figure), it is possible to calculate in a comparative manner the effect of preheating the coal. It is thus of interest to consider at what time after entering the furnace the temperature in the interior of particles of various sizes reaches, say, 350 C. The methods for doing this have been worked out by A. Schack (*Stahl und Eisen*, Vol. 50, 1930, p. 1290). To simplify the calculation, the increase in the specific heat and thermal conductivity of the coal and coke with increasing temperature is neglected, an average figure being taken without influencing the results greatly. The calculation shows that with an initial surface temperature of 500 C and with particles of various diameters, the time taken for the interior to reach 350 C is as follows:

Diameter of particle of coal, mm..	1.0	0.25	0.1
Time, seconds.....	0.38	0.023	0.0038

These times are calculated, it must be emphasized, on the assumption that the surface of the particles is suddenly heated to 500 C as the coal enters the furnace. In practise, a period, approximately constant in duration, must be allowed for any size of particle to attain a surface temperature of 500 C. When these two periods are added the effect of using preheated coal may be very much larger than appears likely from the foregoing calculations. Just how great the effect will be can only be determined experimentally; the discussion here given, however, serves to illustrate that the practise, if it could be adopted, would be valuable in making possible the combustion of large pieces of coal dust, though whether the preheating could be achieved at a lower cost than the finer grinding of coal now considered necessary, remains to be seen.

There can be little doubt that at present the time taken to burn the particle in the furnace is greater than the time taken to raise the coal particle to the temperature of ignition, although there is no definite proof that this is so. (G. E. Foxwell, D.Sc., in *Engineering*, vol. 137, no. 3548, Jan. 12, 1934, pp. 29–30, *tA*)

Coal Specifications

THE author outlines a method which covers both the seller and purchaser in relation to thermal value received and regulates the fuel cost per kilowatthour generated by adjusting the purchase price to meet an increase or decrease in the amount of electricity purchased per pound of coal due to fluctuations in thermal value.

The author gives the following rules for estimating the value of coal:

(1) Each delivery of coal should be freely sampled and tested for moisture content. The inherent moisture of coal is approximately 3 per cent (this amount, in the author's opinion, should be the standard). Moisture content should be calculated with coal dried at 100 C and not on an air-dried basis. The moisture percentage difference between the standard and the coal as received should be added to or deducted from the total weight as received in the consignment under test.

(2) Ash and calorific values should be corrected to the standard against the accepted contract cost per ton by the percentage difference in appreciation or depreciation that they attain on the consignment received. They should be calculated only on the "as dried" standard.

(3) Test samples of consignments should be kept in sealed containers for at least 14 days for further test comparison; in

case of dispute after this period they must be accepted as correct.

In the method described, the moisture in coal, as received, is calculated against a standard, and the weight is corrected as received at the generating station. Losses due to moisture are more pronounced on washed fuels—especially if these are not allowed to drain before delivery. Fifteen per cent moisture content has frequently been noted. Fuel purchase by "analysis" correction removes the risk of adulteration with a lower grade than that originally submitted. The cost per ton has varied on analysis correction by 30 per cent for the same type of fuel.

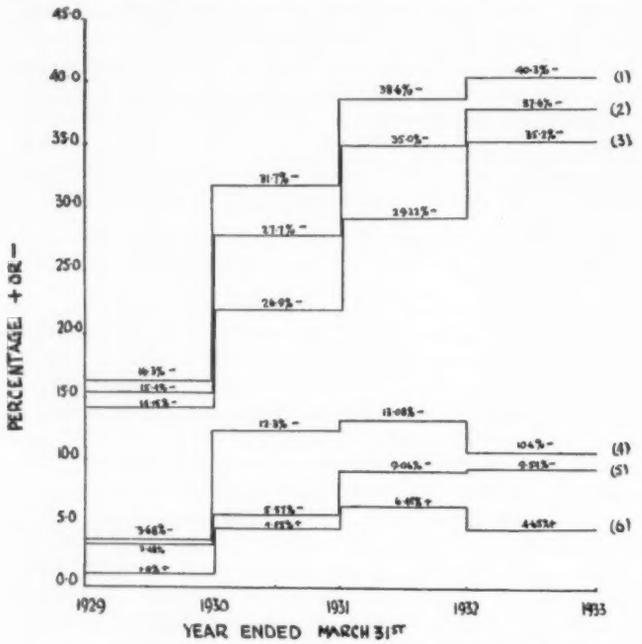


FIG. 9 PERCENTAGE REDUCTION IN COSTS, 1929–33
(1, Fuel cost; 2, pence per kwhr generated; 3, evaporation cost per 1000 lb of water; 4, per lb of fuel; 5, value as fired; 6, lb of fuel per kwhr generated.)

This method of fuel purchase ties the fuel cost per kilowatthour to the primary figure obtained with the standards of all the fuels selected for contract, providing the overall thermal efficiency remains the same. An example of the method of calculation for the fuel purchase on an analysis value of coal per ton and weight correction is given in the original article. After the primary factors have been determined the average boiler and furnace efficiencies with the evaporation cost are found. Boiler and furnace efficiencies may fall with the use of cheaper and lower-grade fuels, but not in direct ratio. The percentage decrease in cost per ton may give a lower evaporation cost notwithstanding a higher fuel consumption. Tests taken over three years at a medium-sized generating station with boilers having an evaporative capacity of 420,000 lb per hr are claimed to demonstrate this point. Analysis of the results obtained shows that to maintain high boiler efficiencies by the use of high-grade fuels is an expensive luxury.

In a station under the author's supervision fuel costs have been decreased by 35 per cent within three years. The increase of ash content from 11.5 per cent to 18.4 per cent did not cause any appreciable rise in handling and maintenance costs; they should not, if the right types of fuels are selected and furnace conditions are carefully noted. The reduction in fuel costs far outweigh any small increase in costs that can be attributed to the use of low-grade fuels. Decrease in evaporation per pound of fuel is pronounced, but the increase in commercial efficiency by a 21.9-per cent reduction in evaporation cost is considerably more noticeable.

If the steam generated were increased to 2,000,000 lb per eight-hour shift (see Fig. 10), the increase in fuel consumption would be 16 per cent, or 13.8 tons on a total consumption of 125 tons costing 11s per ton, compared with 19s in 1929. The fuel consumption increase at the higher steam generation tends to a limiting value of 16 per cent. Between 300,000 and 400,000 lb of steam the fuel increase is 4 per cent, and at 1,500,000 to 1,600,000 lb it is only 0.28 per cent. Fig. 10 shows that fuel consumption does not increase in direct proportion to the steam generated, as combustion conditions are found to be better at the higher evaporation.

The foregoing only appertains to the boiler plant under review, with the types of fuel selected and in use at that plant. For maintaining operating efficiency the best method is to compare steam and coal consumption every eight hours with a definite and predetermined standard derived from the coal- and water-line equations for 12 months.

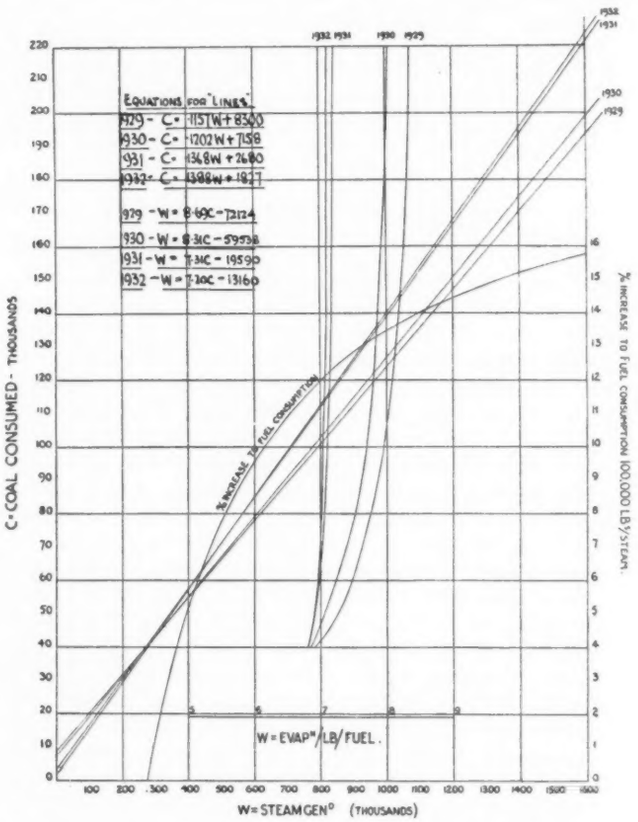

EQUATIONS FOR LINES
1929 - C = 1151W + 8500
1930 - C = 1202W + 7158
1931 - C = 1348W + 2680
1932 - C = 1388W + 1927
1929 - W = 8·69C − 72124
1930 - W = 8·31C − 59538
1931 - W = 7·41C − 19590
1932 - W = 7·20C − 13160
C = COAL CONSUMED - THOUSANDS
% INCREASE IN FUEL CONSUMPTION
% INCREASE TO FUEL CONSUMPTION 100,000 LB/STEAM
W = EVAP" / LB / FUEL .
W = STEAM GEN° (THOUSANDS)

FIG. 10 EVAPORATION LINES FOR 1929–33 WITH PERCENTAGE RISE IN FUEL COSTS PER 100,000 LB OF STEAM

Assuming a standard coal-line equation of $C = 14{,}750 + 1.520\,K$ with an average calorific value of fuel as fired for the period of 11,250 Btu per lb, correction to 10,000 Btu per lb would modify the equation to $C = 14{,}750 + 1.702\,K$. If the coal has a lower thermal value than 10,000 Btu per lb, the equation should be corrected to the lowest calorific value expected.

As an example, assume 80.6 tons (180,300 lb) of coal with a calorific value of 10,700 Btu per lb were used on a shift to

generate 98,600 kwhr, the lb of coal per kwhr = (180,300 — 14,750)/98,600 = 1.68. Correcting to 10,000 Btu for comparison with standard (1.702) we get 1.68 × 10,700/10,000 = 1.797 lb. The difference is 5.3 per cent above standard.

For isolating the cause of an increase in fuel consumption, a steam-consumption standard should be set, e.g., $W = 62{,}500 + 12{,}937\ K$. If the steam required for the shift was 1,350,000 lb, the equation would be (\$1,350,000 — 62,500)/98,600 = 13.06 lb per kwhr, which is 0.95 per cent above standard (12.937). This represents an increase of 12,800 lb of steam, which, at an evaporation of 7.5 lb per ton of fuel, means a loss in fuel of 0.76 ton.

This calculation shows whether an increase in fuel above standard is due to turbine or steam-auxiliary inefficiency. If steam consumption is found to be approximately standard, any rise in the amount of fuel may definitely be attributed to faulty boiler operation, either wasteful firing or boiler inefficiency. It has been found that the methods described have been invaluable in holding operation results to standard. Careless plant operation and inefficiency are at once noticed and losses are limited to eight hours. (T. G. Simpson, *The Electrical Review*, vol. 114, no. 2931, Jan. 26, 1934, pp. 117–118, *pA*)

Colloidal Coal Made From Brown Coal

THE main attraction to German engineers in the use of colloidal coal lies in the fact that it would reduce the consumption of foreign fuel oil. Whether, however, colloidal coal will be able to compete with the extremely cheap foreign fuel oil depends essentially on the method of production of the oil that has to be used with colloidal coal and the cost of the production of a stable coal-oil mixture. The author, Dr. G. Benthin, of the Mining Academy of Freiberg, was commissioned to undertake an investigation of this problem at the instigation of Prof. Dr. Freiherr von Walther and with the support of the Fuel Chemistry Group of the German Chemical Association, in reference to the problem of investigating the creation of a stable coal-oil mixture, especially in reference to the possibilities of producing such a mixture by means of fuel oil from brown coal.

The author found that a brown-coal powder in an oil can be kept from sinking to the bottom by establishing within the oil a fine gel mesh on to which the coal particles can settle. The gel of a soap with its felt-like needles and fibers appears to be particularly stable and the best procedure is to generate the soap in the oil from fatty acids and alkali after the addition of the coal. The amount of the soap depends on the size of the coal particles and viscosity of the oil, but, in general, is about 1.5 per cent. The disadvantage of this arrangement lies in the high viscosity of the material, which makes trouble in pumping, and the possibility of a breakdown of the soap gel with consequent precipitation of the coal particles.

To avoid these difficulties the author has studied the possibility of using the brown coal itself as a source of gel. The coal consists of geologically indigenous lyogels, and in the particular case of brown coals, of hydrogels. As the carbonization proceeds the water content of the gel decreases, but in the case of a brown coal we are still dealing with a gel exhibiting the highest ability of reaction and dissolving easily in an aqueous sud with a nearly instantaneous formation of an alkali humus solution rapidly passing through various stages of the poly-disperse system.

From this hydrogel, by a process similar to that of making oildag from aquadag, an organic gel could be produced by a simple evaporation of the water in the presence of an oil, but the cost of this process would be prohibitive. It is therefore indispensable to produce a xerogel by drying from the lyogel of the brown coal. It so happens that no matter how carefully drying has been carried on and how low the temperature of the process has been, the originally present lyogel loses its capacity for easy dispersion. It becomes necessary, therefore, in swelling the xerogel to look for the dispersion medium in oil and not in water, with the idea of finding a dispersion medium, which favors the swelling and incidentally wets the coal intensively.

Washing soaps have acquired their wetting ability and activity on account of their molecular structure, according to which a long chain of CH_2 is attached to an OH group, which imparts a certain orientation to the entire molecule. It so happens that in addition to waxes and tars soluble in oil, brown coal contains alkali-soluble humic acids with OH and COOH groups which have to be peptized. Therefore, if one selects an oil which contains OH and COOH groups, there occurs (because of the polarity of these groups) an intensive wetting, and, as a result of it, a swelling of the humic-acid section of the brown coal.

Oils of a paraffinic character do not produce any swelling. After having been supported by the turbulence in the oil, the coal particles separate out and their velocity of sinking is a function merely of the viscosity of the oil, size of particle, and the other factors of the Stokes equation. Glycol and glycerine with their excessively short CH_2 chain, possess no orientation with respect to the humic acids belonging to the OH and COOH groups, and therefore do not exhibit any qualities useful in this connection. On the other hand, the OH group having an aromatic nucleus exerts a powerful swelling action on brown coal. Phenatol and anisol, with their etherized hydroxyl group, are entirely unsuitable for this purpose. The ideal oil is the creosote obtained from distillation of brown coal, and in addition to its suitable chemical action it has the advantage of being very cheap. Chemically it is a mixture of phenols and acids with predominance of the higher members, the constitution of which is as yet unknown.

The method by which the action of the oils and stabilizers has been tested consisted in the requirement that the suspension of the coal in oil should show as little as possible clear oil on the top and as little as possible carbon particles segregated at the bottom. The amount of segregated oil and segregated coal in test tubes of a standard size has been determined after a period of several weeks by tilting and rotating the tube and by direct measurements.

The higher the concentration of the creosote employed the more profound has been its swelling action. When the hydrogel of the brown coal is being dried, the water held in its capillaries is driven out and replaced by air which interferes with the wetting of the inner surface of the coal particle. To facilitate the penetration of the creosote, the air is removed by suction and this removal of the air from the mass intensifies the swelling action and produces a greater stability of the mixture. The swelling is speeded up by heating which does not, however, affect much the ultimate result. Sooner or later a certain maximum state of swelling is attained. That swelling actually takes place is shown by the increase in the viscosity of the oil. With oils other than creosote this increase in viscosity does not occur at all or to a similar extent. Up to the time when the maximum of swelling is reached, when there is an excess of the dispersion medium present, the carbon dust sinks in the oil. It is therefore necessary to increase the volume of the occlusive oil, for example, by an addition of soaps. The addition of soaps of the alkali, calcium, and aluminum type made from oil or stearic acids, as well as

stearin, pitch, bitumen, or colophonium, improve certain properties of the coal-oil mixture, but because of their high cost can be used only as very small additions. Their effect is, therefore, less than that of alkalies in concentrated aqueous solution. The use of the latter has been proposed for a similar purpose by the Riebeck Mine Works. This alkali in part forms humates out of the humic acids of the brown coal dust and these humates act as protective colloids in a gel-like distribution. Another part of the humate promotes peptization. The presence of creosote in such a case is advantageous, because the swelling of the coal in the creosote facilitates the formation of the humates, while the acid constituents of the creosote build up soaps which act protectively. The amount of alkalies is governed by the content of coal in the colloidal fuel. An excessive addition of alkalies may promote the solidification of the entire mass and unfavorably affect the ability of the fuel to be handled by pumps. Additions of from 0.3 to 0.5 per cent have proved to be suitable. The efficiency of the alkalies can be further increased by additions of pyridin or mixtures of organic basis, as has also been proposed by the Riebeck Mine Works. That pyridin has a powerful swelling effect on coal is well known. If freshly formed humic acid is beaten up in cresol, it can be separated out by centrifugation, but if pyridin is added first the humic acid is so powerfully solvatized that it cannot be separated by centrifugation any more and can be removed from the mixture only by an addition of "yellow oil." A similar process apparently occurs when pyridin is added to brown coal dust swelled in creosote.

Two types of colloidal fuel have been prepared by the process of peptization of the coal with creosote and an addition of 0.5 per cent alkali. The first contained 33 per cent and the second 25 per cent by weight of brown coal. The specific gravities were respectively 1.11 and 1.09 and the ash content 3.6 and 2.7 per cent as against 10.6 per cent in the original coal. The heat values were 7770 and 8075 kcal as against 9000 kcal for the oil and 5300 kcal for the coal (containing 10.8 per cent of water).

In a vessel of 15 cu cm (probably cubic meter is intended—Ed.) capacity, the following amounts of fuel can be carried:

Fuel oil
(specific gravity 0.97)....14.55 tons with 13.1 million kcal
Coal dust
(specific gravity 0.52).... 7.8 tons with 4.13 million kcal
Colloidal fuel with 25 per cent coal dust (specific weight 1.09).....16.35 tons with 13.2 million kcal
Colloidal fuel with 33 per cent coal dust (specific weight 1.11).....16.65 tons with 12.95 million kcal

It would appear, therefore, that nearly three times as many heat units can be carried in a vessel containing colloidal fuel as in one containing coal dust and approximately the same amount as in a vessel containing fuel oil. (Dr. G. Benthin, paper before Professional Division of Fuel and Mineral Oil Chemistry, 46th Annual Meeting of the German Chemical Society, Würtzburg, June 8, 1933, abstracted through *Angewandte Chemie*, vol. 46, no. 47, Nov. 25, 1933, pp. 742–744, *eA*)

INTERNAL-COMBUSTION ENGINEERING

Bagnulo Multi-Fuel Engine

A DESCRIPTION of the Bagnulo carburetor and cylinder head by means of which any high- or low-speed engine may be adapted to operate equally well on gasoline, alcohol, gas oil, vegetable oils, etc. The essential feature of the head is the mixer or ante-chamber. This is a heavy-walled, spherical chamber, insulated by an air space from the cylinder head proper, in which the fuel is gasified at a constant temperature without access of air. The combustion air is not admitted until just before the end of the stroke. A spark plug fires the charge in the usual manner. All that is required when changing from one kind of fuel to another is simply a change in the adjustments. It is claimed that excellent results have been obtained with all the fuels under actual road conditions. (*Omnia*, December, 1933, pp. 409–410, illustrated. Compare *Automotive Abstracts*, January, 1934, p. 12, *d*)

Special Valve Gear for Research in Internal-Combustion Engines

THIS valve gear has been built by the Armstrong-Siddeley Motors, Ltd., in England, for research in connection with automobile and aero engines. This is a special engine where the three factors governing the valve timing, that is, the lift, the period of opening, and the moment of opening and closing can all be varied independently of one another while the engine is running. This is achieved by the use of two cams only, one operating the exhaust and the other the inlet valve. The engine which is of the single-cylinder overhead-valve type is arranged so that cylinders of various bores can be fitted to the crankcase. The detail of the apparatus is described and illustrated in the original article. (*Aircraft Engineering*, vol. 5, no. 58, December, 1933, p. 307, 4 figs., *d*)

Heavy-Oil-Engine Working Costs

THIS article is based on the Annual Report on Costs prepared by the Diesel Engine Users Association and covering the year 1932–1933. One of the important events of the year for Great Britain has been the imposition of the fuel tax. Among other things the report contains the figures from the Broken Hill (New South Wales) Station which is the largest plant yet included in any report. This station runs at a high load factor (30.8 per cent) and has a low lubricating-oil consumption of 7900 bhp-hr per gal.

The supercharged type of engine has not, as far as the report shows, made the progress that was originally expected. Ashford, which has two supercharged engines, generated 64.4 per cent of the output on these engines and the fuel consumption has been reduced by 10.8 per cent over four years. Owing to the depressed conditions, only three new engines were installed in the stations covered by the report, comprising one 400-bhp and two 225-bhp sets.

Owing to the reduced output of several public supply stations working in conjunction with bulk supply, the average load factor for home stations fell from 12.9 to 12.75 per cent. A saving of 2 per cent in fuel per unit generated is recorded with 4½ per cent more bhp-hr per gal of lubricating oil than in the previous year.

The average fuel per unit generated for all stations was 0.648 lb at an average running plant load factor of 67.2 per cent. Converted at the rate of 19,500 Btu per lb, this consumption corresponds to an average thermal efficiency of 28.9 per cent. The fuel consumption, for the first time since these reports were issued, falls below the standard curve adopted some years ago by Mr. Milton. Out of a total of 54 stations, 29 are below the standard curve, the average being 1 per cent below. Particulars of those stations above the curve are set out in a special table in the original publication as are details of best lubricating-oil consumptions. The

average rated bhp-hr per gal of lubricating oil for all stations was 2385 (54 stations) which compares very favorably with the figure of 1330 (31 stations) obtained ten years ago. Similarly, over ten years, the average cost per unit generated for repairs and maintenance has been reduced from 0.18d to 0.073d.

In the form of a table are given results for British home stations as compared with overseas stations. (*The Electrical Times*, vol. 85, no. 2205, Jan. 25, 1934, p. 112, *pc*)

MACHINE-SHOP PRACTISE (See also Applied Mechanics: Factors Affecting the Grip in Force, Shrink, and Expansion Fits)

Drilling and Boring of Electron

THE electron alloy is extensively used in Germany. Notwithstanding this fact its machining is still not fully understood. The present investigation was carried out at the Experimental Laboratory for Machine Tools and Factory Management of the Technical High School of Berlin and covers drilling and boring. In the course of this investigation an attempt was made to determine under what conditions the chips of electron ignite, which they were said to be apt to do because of their high content of magnesium. It was found that in numerous tests of drilling and in nearly 2800 boring tests there has not been a single instance of ignition of chips, even though some of them ran very hot.

The article points out the possibility of ignition of finely divided electron dust and gives practical recommendations to prevent it. Should it occur, all that is necessary is to throw some cast-iron chips on the fire. Water and the usual fire extinguishing liquids should not be used, as they may contribute to the greater development of the fire.

In practise a good surface can be obtained with a feed of 0.5 mm (0.0196 in.) per revolution, and with feeds of 0.8 to 1.2 mm (0.0315 to 0.0471 in.) per revolution, roughness of the surface appears. It is stated as to drilling that no particular difficulties in handling electron have been discovered, and that tests of considerable duration could be carried on even at cutting speeds in excess of 1000 m (3280 ft) per min. Recommended cutter shapes are given.

As to boring, it is said that when the depth of cut does not exceed five times the diameter of the boring tool, the conventional boring tool operates without the slightest difficulty. From then on the machinability becomes a question of removal of the chip. For small depths and reaming, boring cutters with 12-deg and 25-deg spiral pitch should be used, while for deep boring, tools with helixes of 36 deg and 45 deg should be used. It is further necessary that the boring cutter from the tip to the shaft should have the same cross-section for the passage of the chip. The feeds that have been investigated have been up to 0.5 mm per revolution, with the conclusion that where the holes are not too deep this feed can be applied at once. However, should one want to reach a depth for eight to ten or more times the boring-cutter diameter, it is recommended that a feed of only 0.2 mm per revolution be used.

With such feeds the boring cutter of 36 and 45 deg will give a comparatively good surface, while an increase of torque over the entire length of the bore will be kept within reasonable limits. Successful tests run at 20,000 rpm with boring cutters 5 mm (0.196 in.) in diameter, corresponding to a velocity of about 300 m (984 ft) per min, and some boring cutters of 10 mm (0.393 in.) in diameter, corresponding to a cutting speed of 600 m (1968 ft) per min, shows that as regards cutting speed no close limits need be specified. As a matter of fact the author states that the limitation of cutting speed lies not in the machinability of the material but in the fact that the machine tools will not stand the stresses imposed by excessively high cutting speeds. (Dr. of Engrg. Emil Lingemann in *Maschinenbau*, vol. 12, no. 23–24, December, 1933, pp. 589–593, 11 figs., *e*)

Noisy Running of Hob-Cut Helical Gears

IT MIGHT be assumed that the number of teeth in a gear multiplied by the revolutions per second would equal the number of vibrations per second in the musical note produced. The author found experimentally, however, that this is not so and that apparently some other factor enters here. An examination of a gear so tested showed a series of high spots along the pitch line of the teeth, these high spots being a function of the master gear of the hobbing machine on which the gear was cut. G. A. Tomlinson (*Engineering*, Vol. 125, 1928, p. 599) called attention to such markings as associated with noisy running.

In Fig. 11 the line *CC* represents Mr. Tomlinson's line *AB*. The sketch shows a developed view of the pitch-line periphery of the gear wheel under discussion, on which are imposed the tooth divisions of the master wheel. The spacing and angle of marking on the actual wheel were measured, and exactly agreed with the angles and sizes on the drawing. (The gear had 235 teeth, and rotated at 750 rpm.)

Given the existence of these lines of high spots parallel to the axis, it is reasonable to suppose that these are the actual

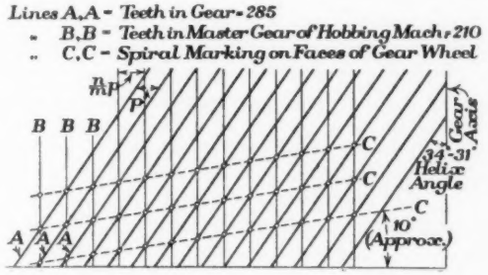


FIG. 11 DIAGRAM ILLUSTRATING GENERATION OF NOISE AS ASSOCIATED WITH MARKINGS ON A HOB-CUT HELICAL GEAR

points of impact, and must be used as such when calculating vibrations.

In the wheel quoted, substituting for $\frac{n}{m}p$ the teeth in gear, master gear, and circular pitch, the following was produced: $\frac{235}{210} \times 0.630 = 0.705$. The number of lines of high spots round the gear equals pitch-circle diameter of gear times $\pi \div \frac{n}{m}p = 47.181\pi/0.705 = 210$. From this figure one can calculate the actual impacts per second. Therefore $\frac{\text{impacts} \times \text{rpm}}{60} =$ vibrations per second $= \frac{210 \times 750}{60} = 2625$. However, as this particular gear was a double helical, and the high spots on the right-hand helix were staggered half-way between the lines on the left-hand helix, this figure must be multiplied by two, producing 5250 vibrations per second. The gear actually produced a note slightly sharp of the eighth octave of *E*, and was tested by an organ pipe from a neighboring church organ. The vibrations of this note are actually 5120 per sec,

working on the correct musical pitch of bottom or fundamental $C = 32$ vibrations.

Another example may be shortly quoted: Gear, 159 teeth, 0.31593 circular pitch, 112 teeth in master gear of hobbing machine, 15.989 p.c.d. of gear, 1258 rpm. Pitch-circle diameter of gear times $\pi \div \frac{n}{m} p = 15.989 \times \pi \div \left(\frac{159}{112} \times 0.31593\right)$ = 112 = number of lines of high spots.

$$\frac{112 \times 1858}{60} = \text{vibrations per second} = 2348$$

In this case the wheel produced a note about the seventh octave of *E*, equivalent to 2560 vibrations.

The foregoing examples tend to prove that there is a definite relation between the high spots on the teeth of an incorrectly cut helical gear and the note produced by the gear in running; in fact, it seems apparent that these spots are the contact points.

This conclusion is very disquieting, for the fact emerges that a helical gear showing this feature is, in actual fact, not a helical gear at all, but is converted, by reason of these contact points parallel to the axis, into a spur gear making contact at only a few places along the face of the gear. The load, therefore, instead of being equally distributed across the whole face of the tooth, is taken on a comparatively small area of each tooth, and all the advantages of the helical tooth with its gradual rolling engagement and constant contact are lost. (W. Hall, *Engineering*, vol. 137, no. 3552, Feb. 9, 1934, pp. 138–139, *eA*)

MARINE ENGINEERING

Motorship "Manoeran"

THIS 15-knot vessel was converted from a 12-knot steamer by the installation of Werkspoor-Sulzer geared Diesel machinery. The engines embody some new features of Werkspoor-Sulzer design and are the first of their type to be placed in service. It was designed to utilize the existing propeller shaft and propeller, which, when the ship was a steamer, ran at between 80 and 90 rpm. As it was desired to employ high-speed machinery, two single-acting engines were installed running at 225 rpm and coupled through reduction gearing through the propeller shaft to return at 86 rpm. Each of the engines has seven cylinders, 560-mm (22.04 in.) bore, and 850-mm (33.46 in.) stroke. Each engine drives its own scavenging pump, but the auxiliary pumps are driven in an unusual manner from the gearing. The exhaust gases are passed through two boilers supplying steam for driving an electric lighting set and other purposes. Airless injection is used and therefore no compressor is needed. There are, in fact, no auxiliaries in service at sea apart from those which derive their power either mechanically or through exhaust gases from the propelling machinery.

The liner is in two sections, the upper part subject to the maximum temperature stresses and the lower portion serving mainly as a guide for the piston. The two parts are flange-bolted together with the flange within the water space. The outer periphery of the wall of the upper portion of the liner is provided with grooves, while there are corresponding grooves on the inner portion of the jacket at the same points. The cooling water is caused to pass around this part of the liner at high speed, and the cooling effect is believed to be more complete than would probably be the case with a normal construction.

For the injection of the fuel into the cylinders the largest Bosch pumps of the type manufactured are used with the working pressure of from 350 to 400 atm. The camshaft is at the level of the bottom of the cylinders instead of at the top. The shaft has cams which lift the plungers of the individual fuel pumps, one in front of each cylinder, and at the aft end of the camshaft is the distributor for supplying compressed air to the various cylinders also actuated from the shaft. There are ahead and astern cams for driving the pumps, but the camshaft itself does not move fore and aft.

Several of the features cannot be described here because of lack of space. Among these are the engine controls, the operation of the starting and throttle levers, and the Sandner damper.

Demag gearing is used and it is claimed that the accuracy attained is greater than has hitherto been thought possible with ground gears. The gears have been cut with worm hobs and the pitch error of the large wheel is only one four-hundred-thousandth of an inch.

The pump drive is said to be unique. Four pumps are formed in one group at the forward end and are driven by a single 750-rpm shaft running underneath the engine-room floor. This shaft is operated by gearing from the Demag mechanical gear at the after end of the engine room.

The scavenging-air intake and delivery pipes are cross-connected in the valve chest and there is an externally operated hand wheel, so that the amount of air delivered can be reduced and the exhaust temperature raised. This allows of a fairly high temperature, even when the power is reduced, and, as one of the illustrations shows, the exhaust from each engine is passed into its own vertical boiler before being discharged to the funnel. The boilers are connected to two oil-fired boilers originally in the ship (three were removed), so that they form virtually one large boiler with a substantial water space. The arrangement has so far worked very satisfactorily. (*The British Motorship*, vol. 14, no. 167, January, 1934, pp. 365–367, 5 figs., *d*)

MOTOR-CAR ENGINEERING

Crossley Streamlined Rear-Engined Car

THE design of this car was worked out under the patents granted to Sir Dennistoun Burney, whose theory of weight distribution requires the provision of considerable masses toward each end of the car. The rear engine complies with this requirement and at the front the radiator and storage battery provide a weight located ahead of the axle. The main reasons for placing the engine in the rear, however, is to reduce the air resistance, for which purpose it is necessary to shorten the forward part and to extend the tail. The drive is taken through a Wilson gear box, spur gears, and hypoid bevel gears to short cardan shafts connected to the rear wheel. Each rear wheel is carried by a substantial torque arm and reacts against a semi-elliptic spring shackled at both ends.

Front wheels are supported by transverse arms and a single cross spring. Hydraulic shock absorbers are used on the front, but have been found to be unnecessary at the rear owing to the dead-beat action of the suspension. The steering is somewhat heavier than on the conventional cars. That the shape of the vehicle has reduced the air resistance is shown by the fact that an engine with a rating of 15.9 hp has been found to be capable of driving the car at 75 mph with the possibility of exceeding 80 mph. (*The Motor*, vol. 44, no. 1671, Jan. 2, 1934, pp. 1082–1084, illustrated, *d*)

Cooling Poppet Valves in Compression-Ignition Engines

THE author deals primarily with the compression-ignition engine and considers a way for cooling the poppet valves in the belief that unless properly cooled they form hot spots and lead to detonation. This applies particularly to the exhaust valves. A new method of cooling these valves is shown in Fig. 12.

Fig. 12 shows how this method is applied to an overhead-type valve and a side valve. The only changes needed are possible increase in the size of the oil pump, the use of hollow exhaust valves, and larger valve guides. In the case of over-

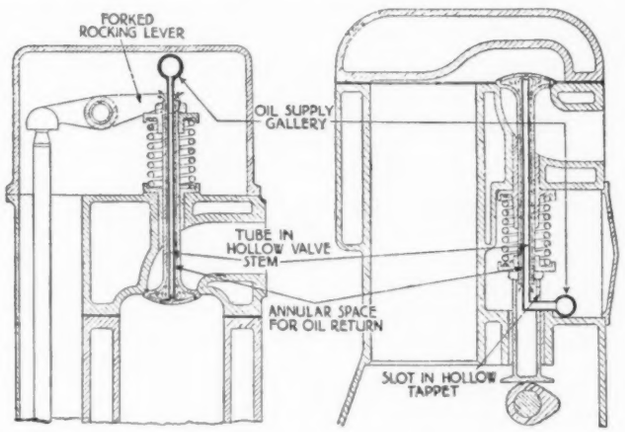


FIG. 12 OIL COOLING OF POPPET VALVES IN INTERNAL-COMBUSTION ENGINES

head valves the rocker arms will have to be forked and with side valves a hollow tappet must be employed with an aperture in the side to accommodate the oil feed pipe. Oil is pumped through small pipes inside the valve stem and returns by way of the annulus between the pipe and the wall of the hollow valve stem. It is said that the rise in the temperature of the oil is very small and no carbonization of the oil inside the valves occurs. (*The Commerical Motor*, vol. 58, no. 1504, Jan. 12, 1934, p. 801, 2 figs., *d*)

Rear-Engined Mercedes Car

THIS car is built by the Daimler-Benz Company in Germany for the small-car market. The engine has a 70-mm (2.75 in.) bore and 85-mm (3.346 in.) stroke. A high-compression head is employed with a compression ratio of six to one, giving the engine an output of 26 bhp at 3400 rpm. The engine is located in the rear. As regards the transmission system, there is the usual clutch casing enclosing a normal single-plate clutch on which is flanged the differential case.

Behind, or rather in this instance forward of this, is bolted the four-speed gear box. The clutch shaft passes through the differential casing to the gear box and a shaft goes from this back to the differential which is driven by an underslung worm gear. The engine is behind the rear axle and the rear wheels are suspended in the usual manner.

The front wheels are suspended between two transverse springs. The body sits astride the central tube and is supported by two cross pieces bolted on by means of bridles beneath the central tube. The car has a wheelbase of 8 ft $2^1/_2$ in. and a track of 4 ft 2 in. and the makers guarantee a maximum speed of 57 mph. (*The Motor* vol. 44, no. 1671, Jan. 2, 1934, pp. 1085–1086, illustrated, *d*)

POWER-PLANT ENGINEERING

The Benson Boiler

THE paper is entitled, "The Influence of the Benson Boiler on the Development of Power Stations," and discusses the design of the boiler, first for critical and then for subcritical pressures. It is claimed that a considerable saving in weight and cost is obtained with it as compared with ordinary water-tube boilers. The author discusses the matter of salt content of the boiler to which reference has been made in MECHANICAL ENGINEERING before (Vol. 55, No. 8, August, 1933, p. 512). As to the design of the boiler, the Benson type is characterized by the absence of drums, which permits great freedom in the arrangement of the tubes and general layout. It also gives a considerable saving in weight and cost. A further saving is obtained by reason of the fact that, because of the narrow tubes employed, the weight of the heating surface is smaller than in normal boilers in which, on account of the natural circulation, much wider tubes are necessary than for the Benson boiler with its forced flow. A figure in the original article is claimed to show the saving in weight achieved by the use of smaller tubes. For very small outputs a Benson boiler may be formed of a single continuous tube. For commercial outputs the subdivision into a number of parallel rows of tubes is indispensable, but the number of tubes connected and parallel and the flow resulting therefrom in the tubes may be chosen freely.

From the basis of experience gained, the elements for the radiation portion are made to consist either of coiled or of straight vertical tubes with headers at the lower end and collectors at the upper end, and of down-tubes leading to the next element. The elements of the convection part consist of separate coils wound clockwise and counter-clockwise, which together form heating elements when inserted into one another. These are provided with supports at the return bends and are built into the boiler as a whole. The general construction of the boiler is discussed and illustrated, both for chain-grate and for pulverized-fuel firing.

Reference is made to the operation of the Benson boiler at variable pressure, as developed by Siemens-Schuckert Works. This consists in omitting the throttling of the steam between the boiler and the turbine. In this way the Benson boiler always delivers steam at the most economical pressure consistent with the load at which the turbine happens to be operating. The details of the underlying theory are given in the original article.

The possibility of operation at varying pressure can be utilized to particular advantage in power stations operating with fluctuating loads, especially where considerable peaks have to be met. In such cases the turbine is designed to take the most frequently occurring base load at the lowest economical pressure and, when the peak loads come on, the steam pressure is correspondingly raised so that the weight of the steam passing through the turbine is similarly increased; thus the volume of steam passing through the turbine remains practically constant, since at constant inlet temperature the specific volume is approximately inversely proportional to the pressure.

If, for instance, a condensing turbine is designed for 500 lb per sq in. (850 F) and a good vacuum, approximately 4.5 times the weight of steam can be passed through the turbine without altering the position of the stop valve, by raising the pressure to 2000 lb per sq in. Of course, it would not be possible to utilize fully the available vacuum in the last stages of the turbine. If, however, a condensing plant, liberally designed for 500 lb per sq in. is retained, then the power developed in

the last stages will remain approximately the same although the vacuum will be somewhat reduced. In Fig. 13 the limiting cases of the lowest load at 500 lb per sq in. and of the highest load at 2000 lb per sq in. are shown in the Mollier diagram. From this it will be seen that both the adiabatic and the useful heat drop remain approximately constant at all loads. Since the total volume is also constant and the Parsons factor of the machine remains practically unchanged, it follows that the thermodynamic efficiency of the machine, and consequently its specific steam consumption, must be constant at all loads. Governor valves are not necessary for the turbine if it operates

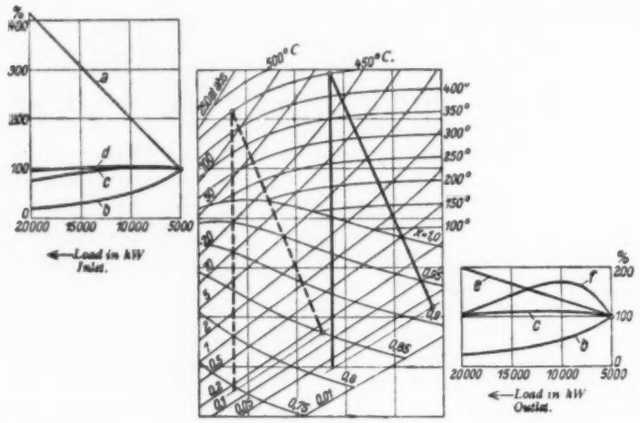


FIG. 13 MOLLIER DIAGRAM FOR OPERATION WITH VARIABLE PRESSURE, WITHOUT REHEATING

in parallel with other machines; overload valves are also superfluous. All that is required is a stop valve, designed for rapid closing, which can be used for throttling in emergencies.

Siemens-Schuckert have evolved a design for a plant unit with extreme variations of load. This is described in the original article containing, among other things, some cost figures. Among other things is discussed the advantage of the Benson boiler in bleeder and back-pressure installations. To illustrate this a Mollier diagram is given for comparison of steam conditions between a normal bleeder turbine and a back-pressure turbine with variable inlet pressure (Fig. 17 in the original article). (F. Ohlmüller, paper before the *Institution of Electrical Engineers*, presented Feb. 15, 1934, abstracted from proof, 10 pp., 17 figs., *dpA*)

SPECIAL PROCESSES

Production of Foodstuffs From Wood

ONE of the foodstuffs made from wood is sugar; Doctor Bergius, for example, has developed a wood sugar. The essential feature of this process is that the sugar solution produced as a result of the reaction between wood and 40 per cent hydrochloric acid is utilized to treat fresh wood, so that the sugar concentration is increased and an equilibrium between the hydrochloric acid and the cellulose is finally obtained. Not more than 10 per cent of the acid is said to be lost. A large factory making such sugar has been in continuous operation since May at Mannheim-Rheinau.

The wood is converted into three components. One is lignum, which can be briqueted and used for fuel as it has a calorific value of 9000 Btu per lb. The acetic acid is recovered in practically pure form, while the sugar contains about 2 per cent of the hydrochloric acid, some moisture, and a small, percentage of inorganic compounds from the wood. It can be used in its primary form as cattle food with good results and after inversion can be fermented to produce alcohol, lactic acid, and other products. It can be converted into chemically pure glucose in either the anhydrous or crystallized states. The development of this process involved the problem of using structural materials completely different from common practise. Thus, it became necessary to construct stoneware pipes, hundreds of yards long, containing scores of valves, and to discover the best material or combination of materials to protect the metal parts from the hydrochloric acid. (Abstracted from an editorial in *Engineering*, vol. 136, no. 3546, Dec. 29, 1933, p. 715, *d*, which in turn is based on a paper read by Dr. Friedrich Bergius before the Institution of Chemical Engineers, Nov. 15, 1933.)

Industrial Education in the South

(*Continued from page 222*)

making, combustion engineering, and mill management have been developed to an unusual degree. The following subjects have been offered in one year under 17 instructors: shop arithmetic, paper chemistry and sulphite process, foremanship, manufacture of soda and phosphate, paper finishing, soda and sulphate process and operation, electricity, blueprint reading, shop accounting, millwright practise, sheet-metal drafting, steam-plant practise, and combustion.

The courses are arranged in lessons in which the scientific theory and principles are introduced in reference to the actual items of equipment in the plant or the process involved in each step of steam generation and utilization. After each lesson, questions and approved answers on the topic are discussed.

The following table shows the total registration and expenditures for trade and industrial classes supported in whole or in part by Federal funds, in the southern states, included in the area studied.

States	Enrolment	Expenditure
Alabama	5148	$ 75,489
Florida	4787	69,162
Georgia	4244	50,514
North Carolina	5984	55,240
South Carolina	5377	72,160
Tennessee	4835	68,800
Virginia	9711	112,864
Totals	40,086	$504,229

In conclusion, considering the rapid development of industrial activity in recent years, the relative position that industry occupies in the general social and economic life of the South, the wider distribution of manufactures in smaller cities, the relative infrequency of extremely large cities, and the comparative lack of wide diversity in manufactures, it would seem that industrial education, outside of the higher institutions, has developed sufficiently to meet the needs of the present.

Looking forward to the day when industry in the South shall develop to a proper economic balance with the raw materials, and the consumption of products in home and outside markets, there is much yet to be done to develop the workers to a higher technical skill and to a higher plane of existence. The groundwork has been done, the industry and the workers are awake to its needs, and the revival of industry and trade will surely be marked with continued advances in industrial education conducted in the industry, primarily for those directly engaged in industrial pursuits, and designed to raise the general standards of service, efficiency, and happiness.

Proposed Rules for the CONSTRUCTION OF UNFIRED PRESSURE VESSELS SUBJECTED TO EXTERNAL PRESSURE

FOR MANY years the pressure-vessel industry has felt the lack of adequate rules for computation of vessels subjected to external pressure such as vacuum tanks, the inner shells of jacketed vessels, and the like. There have been wide variations of practise in this field, dependent upon certain formulas acquired from varying sources, and rather unsatisfactory results have been experienced, as there have been collapses in certain instances and considerable uncertainty about operating conditions in others. Numerous questions have accordingly come to the A.S.M.E. Boiler Code Committee concerning the design and construction of vessels subject to collapsing pressure.

About five years ago the committee made formal request to the Research Committee of The American Society of Mechanical Engineers to undertake the preparation of adequate formulas, either by general investigation or research, for the computation of this class of vessels. The Research Committee acted promptly on the request and selected a special committee that undertook the investigation and studiously and carefully investigated this particular field. It was found that the existing data were very inadequate and considerable investigation would be necessary to check the existing formulas with actual construction. In the course of the work a large amount of experimental work was contributed by the U. S. Navy Department and certain interested manufacturers.

Considerable time was required to interpret the data obtained into form such that it would be useful for code purposes, but the special committee has finally succeeded in outlining rules that will influence safe construction of vessels subjected to external pressure. Report has been made thereon to the Boiler Code Committee and the rules recommended have been accepted for publication as proposed addenda to the Code for Unfired Pressure Vessels. These rules are printed herewith for study and comment.

PROPOSED RULES FOR UNFIRED PRESSURE VESSELS SUBJECTED TO EXTERNAL PRESSURE

Cylindrical Vessels Subjected to External Pressure. The rules for this class of vessels shall apply only to cylindrical vessels of the three types (either with or without stiffening rings) illustrated in Fig. 1, when constructed of steel complying with Specifications S-1 for Steel Boiler Plate, S-2 for Steel Plates of Flange and Firebox Qualities for Forge Welding, S-4 for Seamless Steel Drum Forgings, S-17 for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes, S-18 for Welded and Seamless Steel Pipe, or S-25 for Open-Hearth Iron Plates of Flange Quality, and when operated at pressures not in excess of 500 lb per sq in. and temperatures not in excess of 700 F. Corrugated shells subjected to external pressure may be used in unfired pressure vessels in accordance with Par. P-243 of the Power Boiler Code.

Working pressure shall be the safe operating pressure, which shall be the maximum possible difference in pressure between the outside and inside of the vessel at any time and shall be one-fifth the collapsing pressure.

Shell Thickness. The minimum required thickness of the shell plate shall be determined from the chart as shown in Fig. 2.

In this diagram the abscissas are L/D, the ordinates are working pressures, and the curves represent different values of t/D, where, as shown in Fig. 3,

L = length of vessel between centers of head seams or between centers of circumferential stiffeners, in.
D = outside diameter, in.
t = minimum required thickness of shell plate, in.

In no case shall the external working pressure for which the

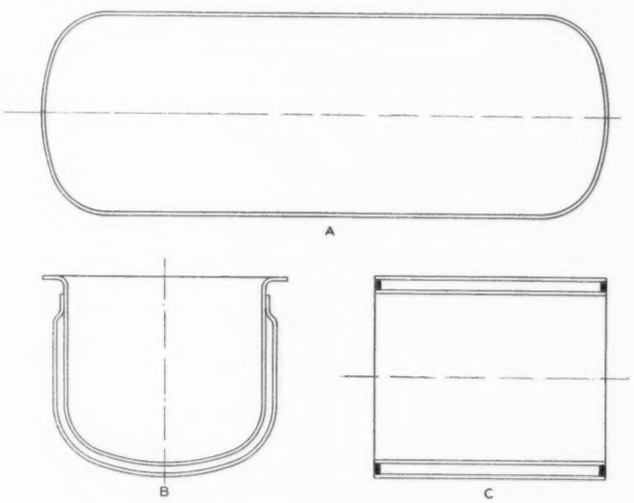


FIG. 1 THREE TYPES OF UNFIRED CYLINDRICAL VESSELS SUBJECTED TO EXTERNAL PRESSURE

vessel is designed be taken as less than 15 lb per sq in. (corresponding to a collapsing pressure of 75 lb per sq in.).

Instructions for Use of Chart. To use the chart, Fig. 2, the value of L/D is computed and, with the given working pressure, the corresponding value of t/D is read off. With this value of t/D, the required thickness t is found. When a vessel has an L/D ratio greater than 20, the same t/D ratio shall be used as for a vessel having an L/D ratio of 20.

Example. Given: Pressure vessel 12 ft long between heads, 96 in. outside diameter, external working pressure 15 lb per sq in.

Required: Thickness, t.

Solution: $L = 12 \times 12 = 144$ in. $D = 96$ in. $L/D =$

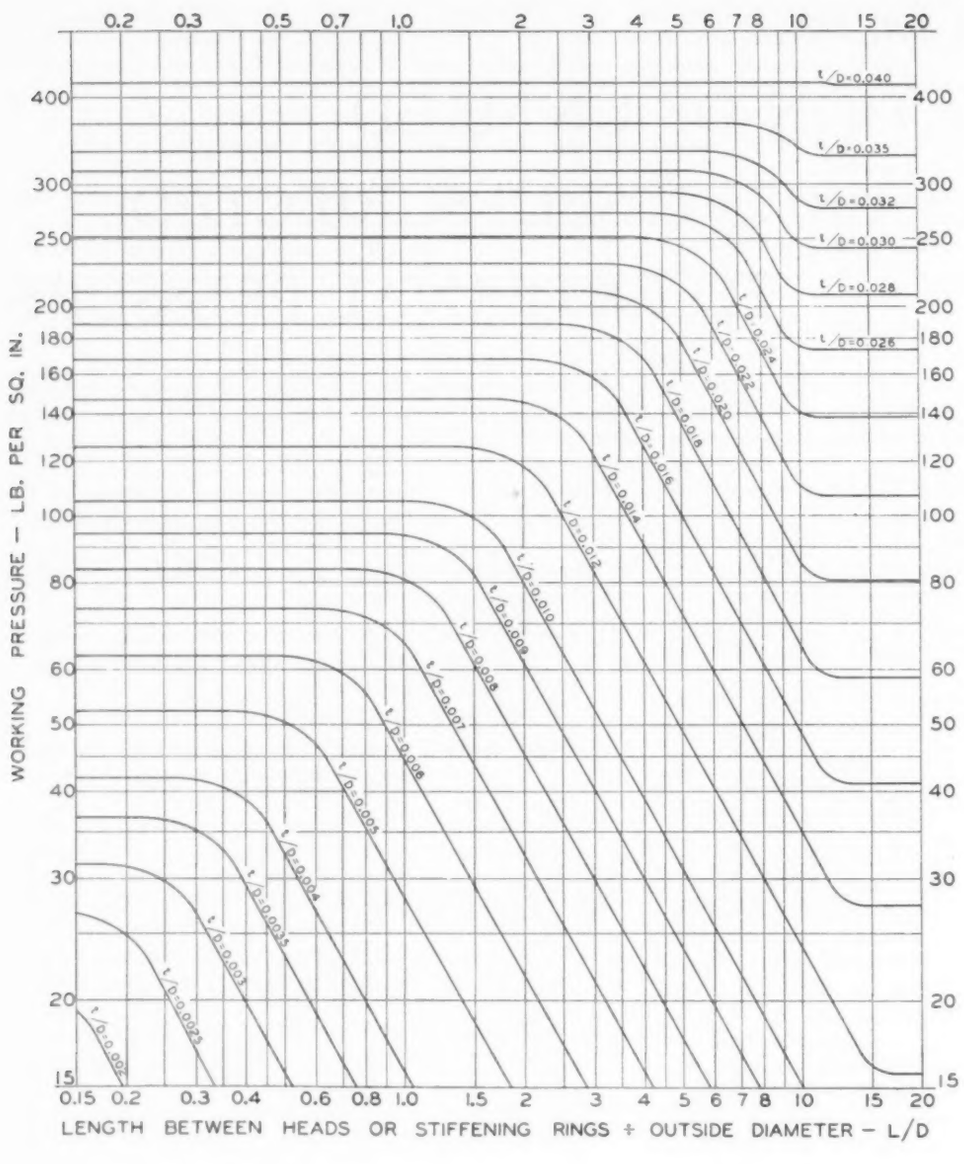


FIG. 2 CHART FOR DETERMINING SHELL THICKNESS OF UNFIRED CYLINDRICAL VESSELS SUBJECTED TO EXTERNAL PRESSURE WHEN CONSTRUCTED OF STEEL COMPLYING WITH SPECIFICATIONS S-1, S-2, S-4, S-17, S-18, S-25

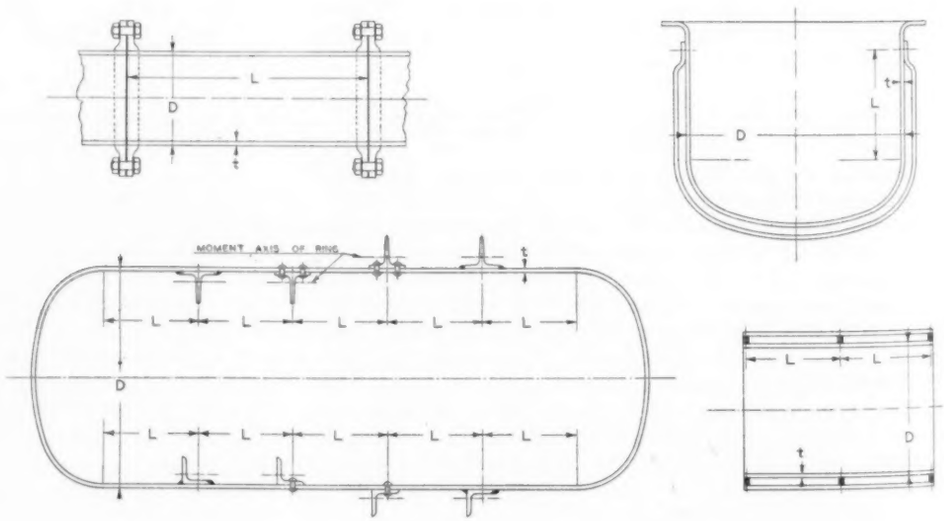


FIG. 3 DIAGRAMMATIC REPRESENTATION OF VARIABLES FOR DESIGN OF UNFIRED CYLINDRICAL VESSELS SUBJECTED TO EXTERNAL PRESSURE

144/96 = 1.5. From Fig. 2, for a working pressure of 15 lb per sq in. and an L/D ratio of 1.5, the ratio t/D is found to be 0.0046. Therefore: $t = 0.0046 \times D = 0.0046 \times 96 = 0.44$ in.

Out-of-Roundness. The out-of-roundness e, or difference between the maximum and minimum diameters in any plane perpendicular to the longitudinal axis of the vessel, expressed as a fraction of the shell thickness, shall not exceed that given by the chart, Fig. 4, except that on vessels having longitudinal joints of lap construction, the difference between the maximum and minimum diameters may be as great as that given by the chart, Fig. 4, plus the thickness of the plate (see also paragraph referring to longitudinal joints, page 249). Measurements shall be taken on the completed vessel in a sufficient number of planes to insure that the entire surface of the shell meets the requirements.

Example. Given: Pressure vessel considered in previous example.

Required: Maximum out-of-roundness permitted.

Solution: From Fig. 4, for a t/D ratio of 0.0046 and an L/D ratio of 1.5, e is found to be 1.0 t.

This means that the difference between the maximum diameter D_{max} and the minimum diameter D_{min} (see Fig. 5) in any plane perpendicular to the longitudinal axis of the vessel, shall not exceed the shell thickness.

Stiffening Rings. Circumferential stiffening rings composed of bars or structural shapes secured to the shell of the vessel may be used, in which case the distance L may be considered as the length, measured parallel to the axis of the vessel, between the centers of adjacent stiffening rings, provided the moment of inertia of the rings is not less than that obtained from the chart, Fig. 6.

Stiffening rings shall extend completely around the circumference of the vessel. Any joints between the ends or sections of such rings, as shown at C, D, F, and G in Fig. 7, and any connections between adjacent portions of a stiffening ring, lying inside and outside the shell, as shown at H in Fig. 7, shall be so made that the full stiffness of the ring is maintained.

Stiffening rings placed on the inside of a vessel may be arranged as shown at A and B in Fig. 7, provided the moment of inertia required by Fig. 6 is maintained within the sections indicated. The moment of inertia of each section shall be taken about its own neutral axis. However, any gap in that portion of a stiffening ring supporting the shell, as shown at A and E in Fig. 7, shall not exceed the length of arc given in Fig. 8 unless additional reinforcement is provided as shown at H in Fig. 7.

Particular attention is called to the fact that any arrangement of the structure which does not permit uniform radial contraction of the shell will weaken the vessel. Internal radial stays or supports for any purpose shall not bear against the shell of the vessel except through the medium of a substantially continuous ring.

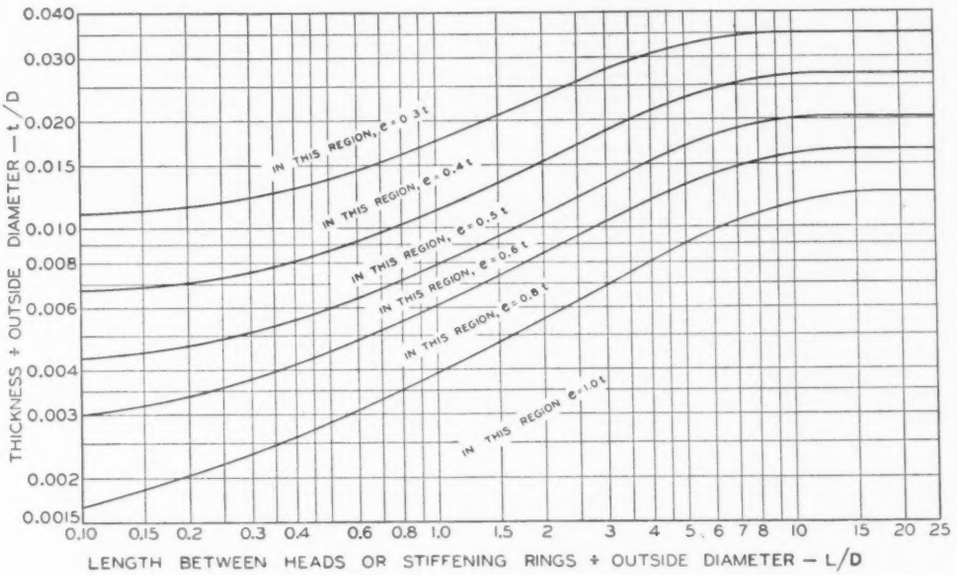

THICKNESS + OUTSIDE DIAMETER — t/D
0.040
0.030
0.020
0.015
0.010
0.008
0.006
0.004
0.003
0.002
0.0015
IN THIS REGION, e = 0.3 t
IN THIS REGION, e = 0.4 t
IN THIS REGION, e = 0.5 t
IN THIS REGION, e = 0.6 t
IN THIS REGION, e = 0.8 t
IN THIS REGION e = 1.0 t
0.10 0.15 0.2 0.3 0.4 0.6 0.8 1.0 1.5 2 3 4 5 6 7 8 10 15 20 25
LENGTH BETWEEN HEADS OR STIFFENING RINGS + OUTSIDE DIAMETER — L/D

FIG. 4 ALLOWABLE DIFFERENCE IN MAXIMUM AND MINIMUM DIAMETERS FOR UNFIRED CYLINDRICAL VESSELS SUBJECTED TO EXTERNAL PRESSURE
(Maximum Diameter—Minimum Diameter = e.)

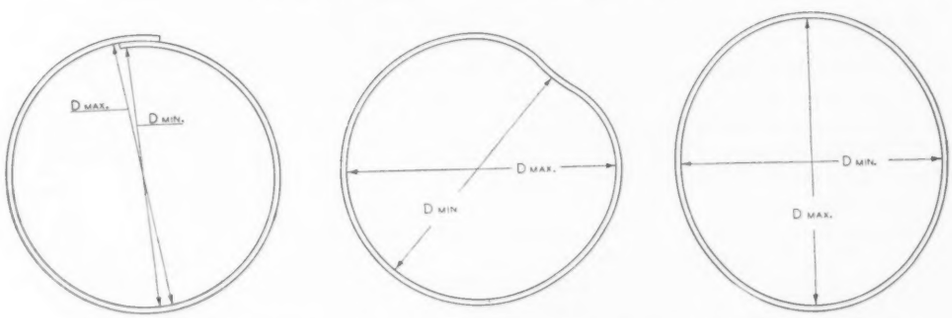


FIG. 5 EXAMPLES OF VARIATION FROM CIRCULAR FORM IN UNFIRED CYLINDRICAL VESSELS SUBJECTED TO EXTERNAL PRESSURE

Example. Given: Pressure vessel 50 ft long, 200 in. outside diameter, working pressure 40 lb per sq in.; to be stiffened by circumferential rings.

Required: Thickness t, best frame spacing L, proportions of stiffening rings, and allowable out-of-roundness.

Solution: If it is desired to use a minimum plate thickness (which will usually be the most economical design), the vessel must be designed with the lowest permissible t/D ratio for the working pressure of 40 lb per sq in. From the chart, Fig. 2, it will be found that this t/D ratio is 0.0038, and the corresponding L/D ratio is 0.25. Then, $t = 0.0038 \times D = 0.0038 \times 200 = 0.76$ in. and $L = 0.25 \times D = 0.25 \times 200 = 50$ in. It should be noted that any further reduction of the L/D ratio below 0.25 does not lower the t/D ratio. Therefore, a spacing of stiffening rings at 0.25 D or 50 in. is the smallest that can be used to advantage.

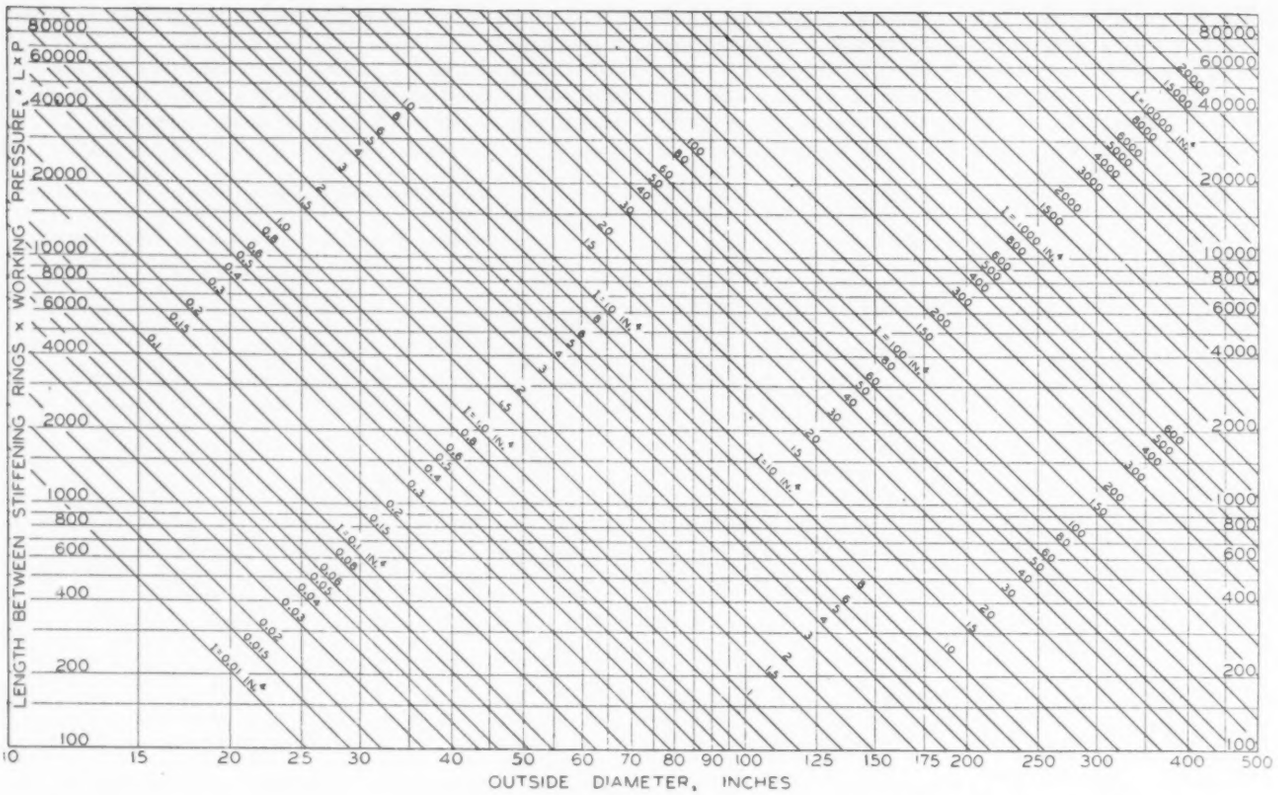


FIG. 6 REQUIRED MOMENT OF INERTIA OF STIFFENING RINGS FOR UNFIRED CYLINDRICAL VESSELS SUBJECTED TO EXTERNAL PRESSURE

The moment of inertia of the stiffening ring is obtained from Fig. 6. For $L \times P = 50 \times 40 = 2000$, and a diameter D of 200 in., I is found to be 96 in.^{4} A 9-in., 30-lb I-beam is shown in standard handbooks to have a moment of inertia I about the neutral axis perpendicular to the web, of 101.4 in.^{4} Such a beam is satisfactory. Stiffening rings must be placed every 50 in. along the vessel, and the shell plate must be not less than 0.76 in. thick.

The maximum out-of-roundness permitted is obtained from Fig. 4. For a t/D ratio of 0.0038 and an L/D ratio of 0.25, e is found to be $0.6t$. That is, the difference between the maximum diameter D_{max} and the minimum diameter D_{min} in any plane perpendicular to the axis of the vessel shall not exceed $0.6 \times 0.76 = 0.46$ in. (approximately).

Attachment of Stiffening Rings to Shell. Stiffening rings, if used, may be placed on the inside or outside of a vessel and they may be attached to the shell by riveting or welding. If the rings are outside and are riveted, the nominal diameter of the rivets shall be not less than the thickness of the shell plate and the center-to-center distance of the rivet holes shall not exceed that shown in Fig. 9.

If the rings are outside and are welded, the total length of the welding on either side of the stiffening ring shall be not less than one-half the outside circumference of the vessel. The arrangement and spacing of such welds, if of the intermittent type, shall be in accordance with Fig. 9.

Stiffening rings placed on the inside of a vessel shall be in adequate contact with the shell and sufficiently secured to the shell to hold them in their proper position under any normal condition of operation.

All welding for attachment of stiffening rings shall comply with the requirements of the code for the class of vessel in question.

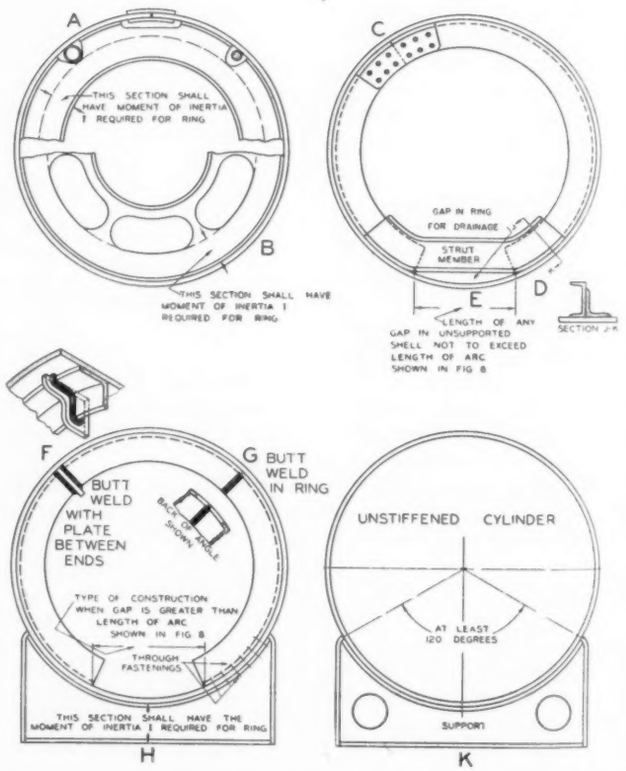

A
THIS SECTION SHALL HAVE MOMENT OF INERTIA I REQUIRED FOR RING
B
THIS SECTION SHALL HAVE MOMENT OF INERTIA I REQUIRED FOR RING
C
GAP IN RING FOR DRAINAGE
STRUT MEMBER
D
E
LENGTH OF ANY GAP IN UNSUPPORTED SHELL NOT TO EXCEED LENGTH OF ARC SHOWN IN FIG 8
SECTION J-K
F
G BUTT WELD IN RING
BUTT WELD WITH PLATE BETWEEN ENDS
BACK OF ANGLE SHOWN
TYPE OF CONSTRUCTION WHEN GAP IS GREATER THAN LENGTH OF ARC SHOWN IN FIG 8
THROUGH FASTENINGS
THIS SECTION SHALL HAVE THE MOMENT OF INERTIA I REQUIRED FOR RING
H
UNSTIFFENED CYLINDER
AT LEAST 120 DEGREES
SUPPORT
K

FIG. 7 VARIOUS ARRANGEMENTS OF STIFFENING RINGS FOR UNFIRED CYLINDRICAL VESSELS SUBJECTED TO EXTERNAL PRESSURE

Supports. The supports for a vessel shall be such that no concentrated loads are imposed which would cause deformation of the vessel in service exceeding the limits of out-of-roundness permitted by these rules.

Note: Attention is called to the objection of supporting vessels through the medium of legs or brackets, the arrangement of which may cause concentrated loads to be imposed on the shell. Vertical vessels should be supported through a substantial ring secured to the shell. Horizontal vessels, unless supported at or close to the ends (heads) or at stiffening rings, should be supported through the medium of substantial members extending over at least one-third of the circumference, as shown at K in Fig. 7.

Attention is called also to the danger of imposing highly concentrated loads by the improper support of one vessel on another or by the hanging or supporting of heavy weights directly on the shell of the vessel.

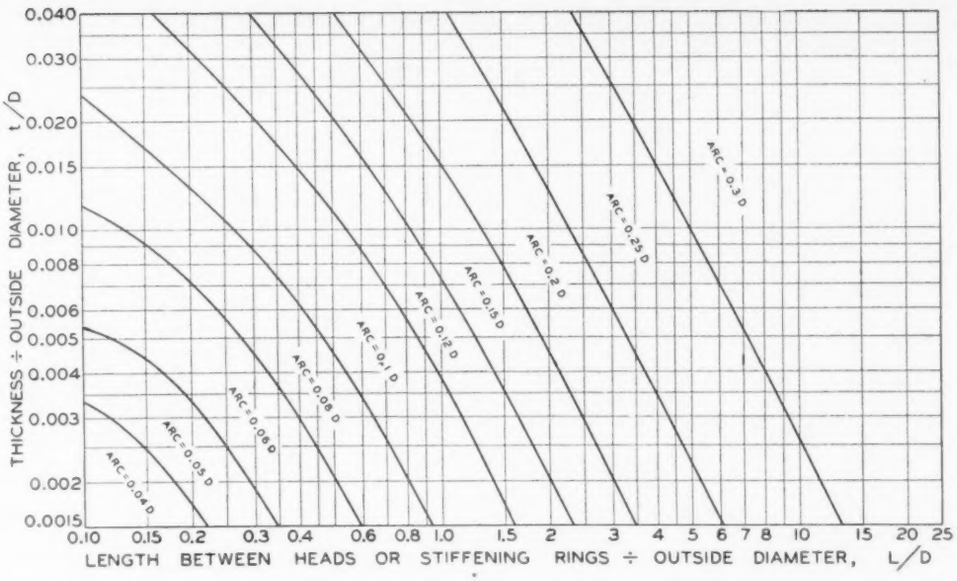


FIG. 8 MAXIMUM ARC OF SHELL LEFT UNSUPPORTED BECAUSE OF GAP IN STIFFENING RING OF UNFIRED CYLINDRICAL VESSELS SUBJECTED TO EXTERNAL PRESSURE

Heads. The design of the heads shall comply with the requirements for dished or flat heads as given in the Code for Unfired Pressure Vessels. Attention is called to the allowable pressure on a dished head when the pressure is on the convex side.

Longitudinal Joints. Longitudinal joints may be of any type permitted by these rules, except that if a lap joint is used,

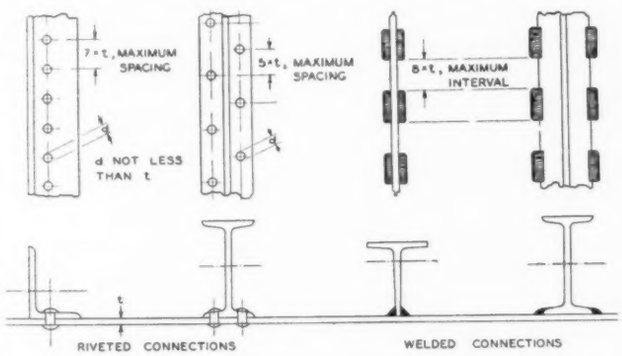


FIG. 9 METHODS OF ATTACHING STIFFENING RINGS TO SHELL OF UNFIRED CYLINDRICAL VESSELS SUBJECTED TO EXTERNAL PRESSURE

either riveted, welded, or brazed, the allowable working pressure shall be 50 per cent of that computed by the rules given herein. Longitudinal joints, if riveted, shall have an efficiency of 50 per cent or greater and in no case less than $PD / S \times 2t$, where

P = working pressure, lb per sq in.
D = outside diameter, in.
S = working stress, lb per sq in., given by Table U-3.

Circumferential Joints. Circumferential joints may be of any type permitted by these rules. The strength of riveted circumferential joints shall be sufficient, considering all methods of failure, to resist the total longitudinal force acting on the joint with a factor of safety of five.

Nozzle Openings. Unreinforced openings in the shell shall conform to the requirements of Par. U-59*a* where

$$K = \frac{\text{thickness required by Fig. 2}}{\text{actual thickness of shell}}$$

Reinforced openings in the shell shall conform to the requirements of Par. U-59*b* where t is thickness required by Fig. 2.

Make the following additions to Paragraphs U-64 and U-66 of the Unfired Pressure Vessel Code:

U-64 *Hydrostatic Test.* Vessels constructed to operate solely under the external pressure of the atmosphere shall be subjected to an internal pressure of not less than 15 lb per sq in.

U-66 *Stamping.* Vessels constructed to operate solely under the external pressure of the atmosphere shall be stamped "vacuum."

Planing *Versus* Milling

(*Continued from page 231*)

consistently replaced the planer wherever they have been brought into proper competition.

The figures on cutting-tool costs submitted by the writer are based on customer practise and while the analysis can be carried much further on the factual data which is available, sufficient evidence has been submitted to show that the whole subject of cost of metal removal has been studied to the extent that actual figures are available and cost results can be guaranteed on this basis.

The writer agrees with Mr. Cardullo that it is an unfair handicap on the planer when it is made to share in the higher cutter-grinder cost of the milling machine, especially when the case is aggravated by having the time taken for tool grinding by the planer operation charged against the planer machine hours on the job. This is obviously a case of inaccurate cost analysis, but another of the many handicaps which this sturdy forebear of the modern milling machine has had to endure in its fight for the right to floor space in the modern shop. Needless to say, if this symposium brings such practises to light it will have served its purpose.

CORRESPONDENCE

Light-Weight, High-Speed Passenger Trains

To the Editor:

In his excellent paper,[1] Mr. Adams has adopted the true scientific attitude which, coupled with sound engineering knowledge, has gone a long way toward convincing even the most steeped skeptic of the enormous possibilities of light-weight rolling stock in the field of high-speed transportation.

Since my chief concern lies with resilient wheels and particularly those of the pneumatic type in which the rubber tire rolls inside of a steel guiding wheel, I would like to question that part of the paper wherein the statement is made that at the present time applications of resilient wheels have been confined to speeds not in excess of 50 mph.

Mr. Adams is probably referring chiefly to the hybrid rubber-insert steel wheel which at high speeds cannot effectively absorb high-frequency vibrations resulting from rail impacts. Due to the fact that the resiliency and hence the impact energy absorption of compressed air is greatly in excess of that of solid rubber, the pneumatic-tired wheel is in a much better position successfully to meet speeds in excess of 50 mph. In fact, existing rail cars equipped with such pneumatic tires have reached sustained speeds of 75 and 80 mph. The load and speed characteristics of these tires, which are encased in hollow steel guiding wheels, are purely a matter of design, as they are not hampered by rail dimensions nor subjected to cuts and bruises caused by breaks on the rail surface. These pneumatic-tired steel wheels have the further advantage of operating safely whenever the hazard of suddenly deflated tires presents itself.

Due to the superior shock-absorbing character of pneumatic tires, the structural framework of the car is relieved of most of the fatigue stresses which are responsible for the existing heavy designs. Furthermore, the use of such materials as aluminum and magnesium alloys, which have a low or mediocre resistance to fatigue in car construction, becomes more possible without any sacrifice in safety.

Walter M. Haessler.[2]

New York, N. Y.

[1] Mechanical Engineering December, 1933, pp. 735–740.

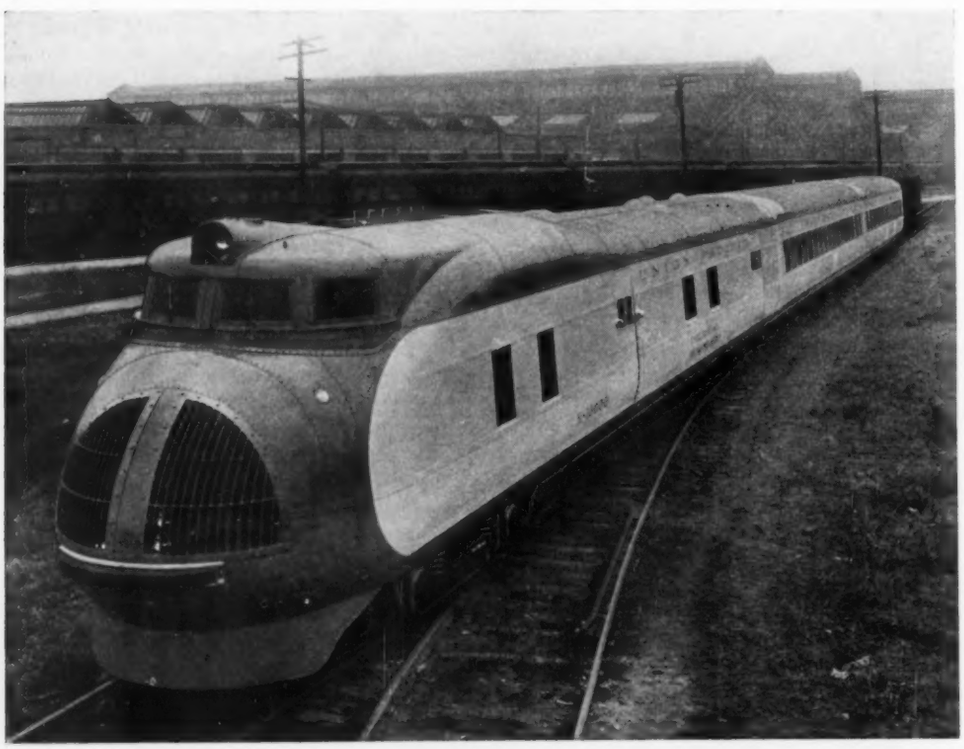
To the Editor:

The present trend in passenger trains is toward high-speed and light-weight cars. Both subjects are very interestingly treated by Mr. Adams.[1] However, it would be advisable to differentiate between light weight and high speed, as the advantages and cost of achievement of each of the two are quite different. Fig. 1 may be of interest in this connection.

Four trains are represented on this chart. In each case a Diesel rail car with two trailers of a total seating capacity for 116 passengers is considered. Two trains are of the conventional heavy type and two of the light (aluminum or special steel) type. One of each couple is made with the conventional blunt front and ordinary accordion-type car connections, while the other is made with streamlined front and car connections, and streamlining all over.

The curves on the chart show the horsepower required for overcoming the resistance of each of the trains on level track at speeds from 30 to 110 mph. The curves were figured on the basis of formulas given by W. J. Davis' article, "The Tractive Resistance of Electric Locomotives and Cars," published in the *General Electric Review*, October, 1926, and it was assumed that 60 per cent of the air resistance of the first car and 30 per cent of that of the second and third cars can be saved by streamlining. The weights and horsepowers required at 110 mph are given in the following table:

[2] Designing Draftsman and Engineer, E. K. Howe & Sons, Inc. Jun. A.S.M.E.



UNION PACIFIC LIGHT-WEIGHT HIGH-SPEED PASSENGER TRAIN

Designation of Train	Weight of train, tons	Resistance power at 110 mph on level track
Heavy, conventional type.....	250	1740
Light, conventional type.....	105	1385
Heavy, streamlined.....	250	1090
Light, streamlined.....	105	735

It is evident from the chart that streamlining, which costs very little, can save 650 hp at 110 mph. The lightening of the train by using costly materials results in a saving of only 355 hp at the same speed. It is true that on heavy grades the difference will be relatively larger in favor of the light train,

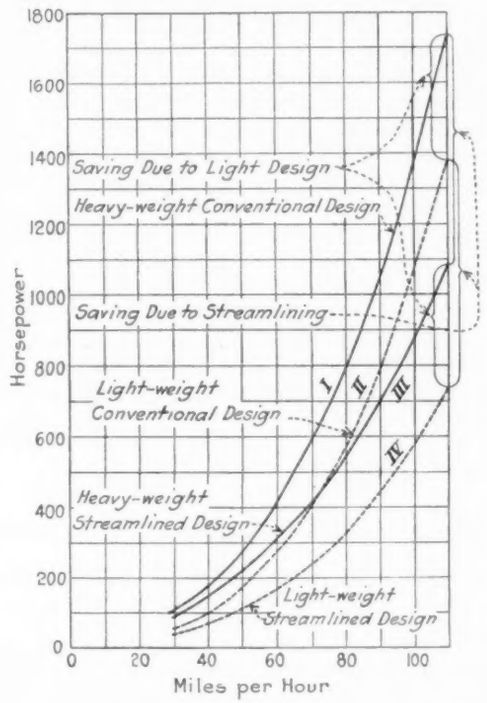


FIG. 1 RESISTANCE POWER ON LEVEL TRACK

but it has to be considered that the speeds on those grades would be lower also.

The heavy train requires a larger power plant, which sometimes may offer difficulties in installing the power plant in a car, but shorter trains with smaller seating capacity could be considered in such a case. There is a vast difference in the achievements of streamlining as compared with lightening of trains, which calls for a thorough investigation of the two questions separately in each individual case, as in some cases it may be found that it does not pay to go to lightening the weight of the cars beyond a certain judicious limit.

A. LIPETZ.[3]

Schenectady, N. Y.

TO THE EDITOR:

The P.L.M. Railway operating between Paris and Marseilles, France, began trial runs during August and October with a train pulled by a Diesel-electric locomotive. The locomotive consists of a chassis or frame mounted on three driving axles and two bogie trucks having a wheelbase of 49 ft 5½ in. and a total weight in service order approximating 220,500 lb.

The Diesel motor of eight cylinders develops 920 bhp, with three speeds, 700, 600, and 400 rpm, coupled to a main generator which supplies current to three tractor motors, and one auxiliary generator that furnishes electric energy to miscellaneous apparatus: fans, compressors, water, and oil pumps, etc.

By the grace of a large oil reservoir of 580 gal, the locomotive can make a course of 625 miles without refueling, burning gas-oil, as demonstrated during the trial runs. The train travels a distance of 540 miles in less than 9 hr between Paris and Marseilles, making usual stops.

It should be pointed out that this train is making better time than our American trains, at one-quarter the fuel consumption, also that Diesel locomotives are now being constructed at a cost approximating that of a good steam locomotive while the working hours per year would approximate 7000 compared with 4000 hours for a steam locomotive.

DIESEL-LOCOMOTIVE THERMAL ECONOMIES

French P.L.M. Railway, 28.2 per cent, Diesel-electric transmission
German State Railway, 26 to 29 per cent, Diesel-compressed-air transmission
Italian State Railway, 30.5 per cent, Diesel-compressed-air transmission
Russian State Railway, 29 per cent, Diesel-geared transmission
American Railway, 7 per cent, steam

Let us not overlook the fact that more than 10 per cent of railway traffic is carrying coal for locomotive and terminal use, which could be eliminated by Diesel engines.

J. GOULD COUTANT.[4]

New York, N. Y.

TO THE EDITOR:

The paper by Mr. Adams[1] is interesting because it covers fully a practical answer to the problem of higher train speeds coupled with economical operation. The comparison made with conventional trains, however, can hardly be accepted as entirely fair A conventional train includes six sleeping cars and an observation car, which, considered as passenger transportation vehicles, must necessarily be inefficient. These types of cars, however, offer comforts and services which are not obtainable in the new three-car train and which would be very expensive to duplicate in an airplane.

There is no doubt that the high-speed trains of the type described in the paper will find many fields of successful application but it would seem that trains affording the convenience and comfort of sleeping cars will continue to be in demand, especially for the longer runs. Are trains of the latter type susceptible of improvement so as to enable them to attain the speed and to approach the low operating cost of the light trains described in Mr. Adams' paper?

In a paper recently published by one of the leading European traction Diesel builders a study is made of this problem and the conclusion is reached that by suitable streamlining it will be possible to operate eight-car trains capable of a top speed of 93 mph at less cost than non-streamlined trains at conventional speeds. Table 1 gives weights, capacities, power, power per ton, weight per passenger, and power per passenger for trains capable of attaining speeds of 90 mph, of the conventional type, of the Union Pacific type, and of the European Diesel, drawn partially from Mr. Adams' paper. It is interesting to

[3] Consulting Engineer, American Locomotive Co. Non-Resident Professor of Locomotive Engineering, Purdue University, Lafayette, Ind. Mem. A.S.M.E.

[4] International Fuel Engineer. Mem. A.S.M.E.

TABLE 1 COMPARISON OF THREE TYPES OF TRAINS

	Train weight, tons	Train capacity, passengers	Train weight including passengers, baggage, etc., tons	Required hp for 90 mph	Hp per ton	Tons per passenger	Hp per passenger
10-Car train[a]	1000	192	1035	3400	3.3	5.4	17.7
U. P. train[b]	80	116	102	500	4.9	0.9	4.3
European 8-car train (streamlined)[c]	580	336	607	3100[d]	5.1	1.8	9.2

[a] Locomotive, head-end car, de luxe coach, diner, 6 Pullman sleepers, observation car.
[b] Power car (baggage and mail), one 60-passenger coach, one 56-passenger coach.
[c] Sulzer-Diesel locomotive, head-end car, seven coaches.
[d] Corresponds to a top speed of 94 mph.

note that the horsepower per ton of train in the case of the Union Pacific is almost the same as that of the proposed Diesel locomotive for a European eight-car streamlined train. The comparison between the two latter trains ends there, as the weight per passenger given for the European train is twice as great, no attempt having been made to calculate savings due to weight reduction.

D. DASSO.[5]

New York, N. Y.

TO THE EDITOR:

The list tabulated by Mr. Adams[1] showing passenger-train-miles and automobiles registered, period 1911–1932, contains food for thought.

Too great stress has been laid on loss of passenger revenues. The drop in freight revenues is, perhaps, where the most constructive work can be carried on by the rail motor car, but beyond doubt its use can help to prevent a further drop in the passenger-revenue curve and perhaps redeem some of this business, as Mr. Adams' paper so ably suggests.

What shall be done about the falling freight revenues, variously estimated at 10 to 15 per cent?

Here, indeed, the bulwark of railroad revenue is being assailed by the truck operator. The issue must be faced and wider highways, one-way traffic, high-speed trucks, and trailers capable of sustained speeds of 60 mph are not merely conjecture but probabilities that will mature during the next decade. The eventual decline in freight revenue must follow the passenger-revenue curve if the railroads do not meet the situation with greater speed and store-door delivery at competitive prices.

How is this to be accomplished? Although trucks have made some inroads into car-load lots, I shall confine this discussion to L.C.L. shipments where the encroachment has been most severe. Here fast rail motor-car freight trains hauling lightly constructed box and flat cars suitable for container service could be utilized. Such oil- or gas-electric trains could be met by railroad or contracted truck service and deliver days in advance of their competitors—if trucks were designed and coordinated for container service the natural trend would be more nearly consummated. Such trains operating at low cost per mile with a high degree of availability should be a profitable undertaking to which shippers would subscribe wholeheartedly if all contingencies were met.

[5] Sulzer Bros., Ltd. Mem. A.S.M.E.

The difficulty today with so-called super-speed freight-train service is the fact that there is not *enough* advantage over ordinary truck service, especially where pick-up at destination has to be performed by the recipient of the merchandise. However, with rail-car freight service coordinated with store-door delivery, the superiority over truck service would be so, evident that there would be no question on the shipper's part which service to adopt. Surely if trucks hauling 10 to 40 tons or so can make their investment profitable—and they certainly seem to stay in business—a rail motor-car freight train operated at less than 50 cents a mile could be made to pay.

Space does not permit lengthy discussion of the many ramifications connected with rail motor-car freight service but it appears possible of adoption at reasonable cost and with its greater speed and lower operating cost should not only arrest the dip in the freight-revenue curve but gradually help to turn the tables on the truck operators in most promising fashion.

Is there, indeed, any other way of solving these problems of declining revenue except to provide more efficient service? Undoubtedly, regulation is necessary and will come in the bus and truck field but, in the final analysis, the very fact of regulation and organization will really result in more efficient operation by the highway operators. Heavier and more powerful locomotives will not help the situation and electrification appears financially overwhelming. Let the railroads hold the present passenger business and improve it if possible by use of high-speed, streamlined, light-weight, rail motor-car trains operating at low cost by all means, but by far the most serious undertaking to be acted on is the preservation of the railroads' most dearly cherished bulwark, freight-transportation revenue.

E. O. WHITFIELD.[6]

New Haven, Conn.

The Relation of Industrial Recovery to Management and Production Control

TO THE EDITOR:

Professional economists, monetary experts, production and management engineers make the statement that industrial recovery must follow the path of decentralization. Industrial decentralization is not of itself an end to be attained, but is rather a means toward governing distribution in such a manner as to bring consumers' cost more closely to producers' cost, or, to reduce non-productive costs. Scientific management and production control, therefore, will be two highly influential factors in its accomplishment.

Scientific management may be described as the scientific and orderly method of approach to the problem of handling men, methods, materials, and machines. The application of this term was first made to productive industries, but, although its widest branch may still be found in production, recent years have seen it applied to underlying principles in transportation, merchandising, and other fields. Production control is a much narrower term and finds its chief application within the factory doors. Its definition implies that it controls or governs the various elements of a productive enterprise, fixing their movement in relation to each other in order to attain a systematized program of production.

Apparently it is a problem of management to investigate and bring to light inefficient and costly distribution problems, unbalanced marketing, and all associated errors. In order to analyze these problems intelligently it must be borne in mind

[6] Former supervisor of automotive equipment, New Haven Railroad.

that industry cannot blame its depressed condition on the rapid growth of the machine age and on overproduction. Only by digging beneath the surface of the problem will it realize that the machine age grew more rapidly than the ability of the human mind could cope with the problem of providing for a better balance between production and distribution of consumers' goods. Surface indications are never a true measure of merits or faults.

Industrial decentralization, a means of adjusting the balance between productive and non-productive work, is a problem of such complexity that management must adjust itself to handle men, methods, materials, and machines, not for the purpose of organizing and of building up huge competitive interests, but for the regulation of national industry on a collective basis. This can be set forth as a problem in production control, all productive and non-productive work being considered as the elements of a productive enterprise, and their relation and balance worked out to attain a systematized program of greatest benefit both for productive and non-productive workers.

A careful examination of such a management structure would reveal something analogous to industries within an industry. Each one, such as the manufacturing, mining, agricultural, merchandising, transportation–all forms of service, whether productive or non-productive—would be an element of a single gigantic enterprise, representing the intrinsic wealth of the nation, and existing for the sole purpose of maintaining an industrial balance, so that a living can be provided for any one who is willing to work. This form of management would in no way endanger or minimize honest and legitimate competition, nor would it retard scientific progress. Both would be encouraged, for under such a scheme of management, machines, as well as all improvements brought about by scientific research, would be made to work for man and not replace his means of living.

Scheduling, routing, dispatching, product design, maintenance, purchasing, selling, shipping, accounting, etc., bear a definite relation to each other, and without proper regulation as to size and importance of each, without cooperation between these various elements, the enterprise is doomed. Failure of one element to meet its obligations spells serious consequences for the entire organization. Similarly, productive and non-productive industries bear a definite relation to each other, and failure of one, or a group of them, to satisfy the demands brought to bear upon them by their relationship with the complete industrial set-up will spell, and has spelled, serious consequences for all.

Scientific management, whether it uses decentralization or other means to bring about industrial recovery, will do well to examine collective industry, as it has the elements and workings of a single plant.

CARL ENDLEIN, JR.[7]

New York, N. Y.

BOOK REVIEWS AND LIBRARY NOTES

Steam Power

DAMPFKRAFT, BERECHNUNG UND BAU VON WASSERROHRKESSELN UND IHRE STELLUNG IN DER ENERGIEERZEUGUNG. By Friedrich Münzinger. Julius Springer, Berlin, 1933. Cloth, $7^3/_4 \times 10^5/_8$, 348 pp., 566 figs., supp. plates, 40 rm.

REVIEWED BY W. J. WOHLENBERG[1]

"WITH the publication of this work I have satisfied an urge which the firm of Julius Springer aroused in me 16 years ago. . . . The book 'Dampfkraft,' for which I have used my former publications as building stones, is occupied primarily with the calculation, construction, and maintenance of boilers. The core of this book is provided by my volume on boiler calculations which was published in 1929 and which today is in general use in boiler factories."

These sentences are translated from the preface of the excellent book "Dampfkraft," by Friedrich Münzinger. They comprise a concise statement of the idea or motif back of the work and of what it contains. The book is divided into ten chapters or parts and deals with all phases of boiler and steam-generator design. All important systems of steam generation in use are considered in some detail. In addition, a considerable amount of discussion and data are included concerning some of the very recent developments which at the present time are still in an experimental stage.

The theoretical background appears to have been drawn from the best sources available. The problems of circulation in boilers and heat transfer, both in the furnace and in other parts of the steam generator, are dealt with in an exceptionally able manner. A number of charts to aid in calculations are included in a pocket at the back of the book.

A part of the book which should prove of considerable value is the inclusion of numerous sample calculations. These are carried through in sufficient detail to make them easily understood. In this connection there are included also many well-chosen illustrations.

There are but a few modern books in which the subject matter is devoted primarily to the particular field of steam generation. Of these this one appears to the writer to stand alone. It sets a very high standard indeed, both in subject matter and as an exhibit of the art of printing engineering literature. It would be a choice and useful addition to the library of an engineer.

[1] Professor of Mechanical Engineering, Sheffield Scientific School, Yale University, New Haven, Conn. Mem. A.S.M.E.

A.S.T.M. Book of Standards

AMERICAN SOCIETY FOR TESTING MATERIALS—STANDARDS. Issued Triennially. Published by the Society, Philadelphia, 1933. Cloth, 6 × 9, tables and illus., Part I, Metals, 1002 pp., $7.50; Part II, Non-Metals, 1298 pp., $7.50; both volumes, $14. (Half leather, $9 per volume, $17 for both volumes.)

AMERICAN SOCIETY FOR TESTING MATERIALS—TENTATIVE STANDARDS. Published by the Society, Philadelphia, 1933. Cloth, 6 × 9, 864 pp., illus., diagrams, tables, $8. (Paper, $7.)

AMERICAN SOCIETY FOR TESTING MATERIALS—PROCEEDINGS. Published by the Society, Philadelphia, 1933. Part I, 1092 pp., Part II, 804 pp. Cloth, 6 × 9, $6 per part; $5.50 in heavy paper binding; $7 half-leather.

THE two volumes of the book of standards contain all of the standard specifications, methods of test, recommended practises, and definitions formally adopted and issued in 1933.

[7] President, Endlein Engineering Corp. Jun. A.S.M.E.

PART I—METALS

Part I (first of the two volumes) contains the A.S.T.M. approved standards for metallic materials, both ferrous and non-ferrous, while Part II contains the standards relating to non-metallic materials. In both parts of the book, the specifications for a particular class of material are given first, followed directly by the test methods, definitions, etc. A subject index and two tables of contents are included in each volume.

Of the 185 standards in Part I, 104 cover the ferrous metals, steel, wrought iron, pig iron and iron castings, and ferro-alloys; 70 cover non-ferrous metals, including aluminum and magnesium alloys, copper and copper alloys, lead, nickel, zinc, bearing metals, solder metal, deoxidizers, electrical-heating and electrical-resistance alloys, and 11 deal with metallography and general testing methods.

Included within this group are many new standards which did not appear in the 1930 book. The following materials are covered by these new specifications: austenitic manganese-steel castings, copper water tubes, electrical-resistance alloys (accelerated life test, test for thermoelectric power), fire-refined copper other than lake, heat-treated carbon-steel helical springs, lap-welded and seamless steel and lap-welded iron boiler tubes, marine-boiler steel plates, open-hearth iron plates of flange quality, seamless copper tubing, soft-steel track spikes, steel plates of flange and firebox qualities for forge welding, structural rivet steel, and structural steel for ships.

PART II—NON-METALS

Part II contains the 285 standard specifications and test methods dealing with non-metallic materials approved to date. They cover the following general classes of material: cement, coal and coke, concrete and concrete aggregates, electrical insulating materials, gypsum, lime, masonry building units (brick and building tile), naval stores, paints, varnishes, lacquers and paint materials, petroleum products and lubricants, pipe and drain tile, refractories and firebrick, road materials, rubber products, slate, textile materials, thermometers, and timber and timber preservatives.

A total of 37 new standards for various non-metallic materials were approved and adopted in 1933. The materials and tests included within this group of new standards are asbestos electrical tape, boiled linseed oil, chafer tire fabrics, crankcase oils (dilution test), enameling duck for tire industry, fire tests of construction materials, gypsum and gypsum products (testing), insulating materials (resistivity test), knit goods (tolerances and tests), linseed-oil putty for glazing, petroleum and its products (sampling), raw tung oil, shellac (dry bleached and orange), shellac (sampling and testing).

TENTATIVE STANDARDS

The 1933 book of A.S.T.M. tentative standards contains 223 tentative specifications, methods of testing, definitions of terms, and recommended practises covering materials of engineering and the allied testing field. Of these 223 tentative standards, 34 relate to ferrous metals; 21 to non-ferrous metals; 45 apply to cement, lime, gypsum, stone, concrete, and clay products; 113 cover miscellaneous materials such as paints, petroleum, insulation, textiles, etc.; while 10 are general testing methods applying to these materials. The term "tentative" applies here to a proposed standard published for one or more years with a view of eliciting criticism before it is formally adopted as standard by the society.

It is interesting to note that during the past three years a considerable number of these A.S.T.M. standards have been presented to and approved by the American Standards Association. A rough count indicates that more than 90 have already received the added national recognition which goes with such approval.

The standards in these books are assembled in a sequence determined by the specific materials or products to which they apply. For convenience in using these volumes each part is provided with two tables of contents, one a listing of the standards in the order in which they appear in the volume grouped according to the subjects to which they relate, the other a listing of the standards in numerical sequence of their serial designations.

A complete subject index appears in the back of each volume in which the standards have been indexed under appropriate keywords according to the materials or subjects to which they apply. The user of these volumes would be greatly helped, however, if an asterisk or some other character were placed alongside of each listing of a specification or test which had received approval as an American Standard or American Tentative Standard.

A.S.T.M. PROCEEDINGS FOR 1933

The Proceedings of the American Society for Testing Materials for the year 1933 are published in two volumes, Parts I and II. Part I contains the annual reports of 40 A.S.T.M. standing and research committees together with the reports of the sectional committees organized under the procedure of the American Standards Association for which the A.S.T.M. is sponsor or joint sponsor. These committee reports cover standardization activities and also discuss the progress and results of extensive research projects sponsored by the various groups.

All of the formal technical papers presented at the 1933 annual meeting of the A.S.T.M. with the extensive oral and written discussions are included in Part II of the Proceedings. For convenience, papers dealing with metals appear together, and the others on cement and concrete, ceramics, masonry materials, and miscellaneous are also grouped.

Two of the technical contributions are outstanding—the lecture on "Crystalline Structure in Relation to Failure of Metals—Especially by Fatigue" and the Symposium on Cast Iron. The former was delivered by Dr. H. J. Gough, of England, and is based on his extensive research work of over ten years at the National Physical Laboratory. The symposium was jointly sponsored by the American Foundrymen's Association and A.S.T.M. and was prepared by a committee of outstanding authorities on cast iron. It presents concise, authoritative data on the composition, metallurgy, and properties of the many grades of cast iron now available. Then follow groups of papers dealing with the development and application of tests for specific properties of metals, both ferrous and non-ferrous.

Several papers in the non-metals group on the various problems in the cement and concrete field have aroused much interest including the following: status of specifications for hydraulic cements, durability of cement mortars, further studies of paving concrete (the effect of vibration and delayed finishing on the quality of pavement slabs), a rapid method for determining the specific surface of portland cement and the effect on volume changes, compressive strength, and heat generation of adding siliceous materials to portland cement. Papers of interest in connection with ceramics and masonry materials include tests on brick masonry beams, permeability of brick masonry beams, and strength, water absorption, and weather resistance of building bricks produced in the United States.—C. B. LeP.

WHAT'S GOING ON

A.S.M.E. Aeronautic Division Reorganizes

THE Aeronautic Division of The American Society of Mechanical Engineers has recently reorganized, setting up a general committee on which will serve advisory groups representing all fields of aeronautics and the interests of other divisions of the A.S.M.E., such as ventilation, petroleum, Diesel engines, marine engineering, hydraulics, machine design, railroad engineering, and the iron and steel industry. The object of the reorganization is "to encourage and assist in the development of useful technical data in the field of aeronautics, and to cooperate with interests in other fields of engineering in the exchange and dissemination of mutually useful information."

Prof. Alexander Klemin is chairman of the newly reorganized division and Jerome Lederer is secretary. Other members of the executive committee of the general committee are E. A. Sperry, Prof. B. M. Wood, Major J. H. Doolittle, and R. M. Mock.

Actions of A.S.M.E. Executive Committee

IN TRAVELING to Cincinnati for the meeting of the A.S.M.E. Executive Committee on March 3, the president and members of that body attended enthusiastic gatherings of ten local sections and eight student branches and attended in a body an excellent dinner and meeting of the Cincinnati Section.

At the Executive Committee meeting, important actions included the adoption of resolutions on the death of the Hon. James Hartness, past-president, the referring to the American Engineering Council of a communication from the A.S.M.E. Metropolitan section decrying the inequitable disparity between wages paid engineers and laborers by the CWA, and the adoption of a resolution urging continuation of Government support of the scientific work of the Bureau of Standards.

Six standing committees had notified the Executive Committee that they were willing to accept a Junior member to their groups in an advisory capacity and asked early appointment of the Juniors. The term of each junior so appointed will be one year with privilege of reappointment for not more than two additional terms. The Denver meeting date was decided upon as June 25 to 28. The Nominating Committee was authorized to meet in Denver and it was voted to assemble a quorum of the Council for the meeting.

Even though the present method of publishing Transactions makes divisional registration no longer necessary for distribution purposes, it was decided to maintain the registration of every member in two divisions as an evidence of their interests. The printing of the Membership List in the same size as Transactions was discussed but no action was taken.

Attention was called to the misuse of the A.S.M.E. clover-leaf emblem by individual members and steps were taken to prevent such use.

A large amount of time was devoted to a discussion of finances, members in arrears, and related matters. Encouraging progress was reported but further efforts are necessary.

Water-Hammer Symposium Soon to Be Published

THE Water-Hammer Symposium soon to be published includes seven papers and the comprehensive committee report originally presented at the A.S.M.E. Semi-Annual Meeting last June, under the joint auspices of the A.S.M.E. Hydraulic and A.S.C.E. Power Divisions. Fifty pages of discussion, and three additional papers dealing with important aspects of the problem not covered by the original papers have been added. Price, $2; to members of the A.S.M.E., A.S.C.E., and A.W.W.A., $1.50 each. Address Publication-Sales Department, A.S.M.E., 29 West 39th Street, New York, N. Y.

Coming A.S.M.E. Meetings

TULSA, OKLA., MAY 14 TO 16

AT THE National Petroleum Meeting, Tulsa, Okla., May 14 to 16, under the auspices of the Mid-Continent Section of The American Society of Mechanical Engineers and in connection with the Tulsa International Petroleum Exposition, there will be an exhibit of automatic and remote-control pipe-line pumping stations. The 1934 exhibit will include many improvements made in the demonstration units exhibited at the 1930 exposition. Four types of stations, which have been erected at a cost of $90,000, will be shown. Station No. 1 houses a motor-driven oil-gathering unit which discharges to a booster station, No. 2, which is also equipped with a motor-driven unit. Station No. 3 is a receiving station and is equipped with tank, flowmeter, and a remote-control equipment for shutting down the booster station. Station No. 4 is equipped with a main-line centrifugal booster pump fitted with remote-control apparatus.

More than 20 papers will comprise the technical program of the National Petroleum Meeting. Refining subjects covered are: heat transfer in pipe stills, heat-transfer rates in heat-exchange equipment, fouling and baffling of heat-exchange equipment, minimum thickness to which refining equipment may be allowed to corrode, and combustion of refinery fuels. The complete program will be announced later.

BERKELEY, CALIF., JUNE 19 TO 21

The National Aeronautic-Hydraulic-Hydrology Meeting, under the auspices of the Aeronautic and Hydraulic Divisions and the San Francisco Section of The American Society of Mechanical Engineers, will be held at the University of California, Berkeley, Calif., June 19 to 21, in connection with the Summer Meeting of the American Association for the Advancement of Science. The tentative program for Tuesday provides a session on general fluid mechanics, in the morning, and three simultaneous sessions on aeronautics, hydraulics, and hydrology and irrigation, in the afternoon. On Wednesday morning the session on fluid mechanics will be continued, while in the afternoon there will be sessions on aeronautics, the hydraulics of pipe lines, and hydraulics in agricultural. On Thursday morning, at Stanford University, the program provides for further simultaneous sessions on aeronautics, hydraulics, and hydrology and irrigation.

Dr. William F. Durand is honorary chairman of the Committee on Arrangements, of which Prof. B. M. Wood is chairman. Chairmen of the subcommittees are as follows: J. E. Younger, aeronautics; M. P. O'Brien, hydraulics; R. L. Daugherty, hydraulic machinery; Frank Wills, long pipe lines; Nathan A. Bowers, hydraulic problems of civil engineering and agriculture.

STATE COLLEGE, PA., JUNE 20 TO 23

The National Meeting of the A.S.M.E. Oil and Gas Power Division will be held in cooperation with the Pennsylvania State College at State College, Pa., June 20 to 23. An exhibit of Diesel-engine parts and accessories will be a feature of the meeting. Arrangements at State College are under the charge of Prof. F. G. Hechler. Prof. K. J. de Juhasz is arranging for the exhibits. The technical program is being set up by L. H. Morrison, E. J. Kates, and Louis Ford. The program will include the 1933 Report on Oil Engine Power Cost for which data are now being collected.

DENVER, COLO., JUNE 25 TO 28

The engineering and mechanical features of the Boulder Dam will provide material for a group of papers to be presented at the Semi-Annual Meeting, Denver, Colo., June 25 to 28, of The American Society of Mechanical Engineers. A motion picture, showing the development and construction of the dam and the machinery, will be a feature of the program. Dr. Ellwood Mead will deliver an evening address on the activities of the Reclamation Bureau. Other papers will discuss the mechanical features of the large hydraulic valves and gates, the construction of the hydroelectric generating units, and the fabrication of the largest pipes in the world. Both of the latter papers deal with the applica-

tion of fusion welding. The Denver committee is also planning an exhibit covering the activities of the Reclamation Bureau, including maps, photographs, drawings, and architectural models.

Side trips will also be a feature of the meeting and will include a trip to Mt. Evans over the highest automobile road in the world.

The general chairman of the Semi-Annual Meeting is Arthur Halliwell. Chairmen of the various subcommittees are C. A. Ahlquist, F. H. Prouty, F. E. Shepard, Dan McQuaid, R. W. Morton, R. H. Fox, J. A. Hunter, H. B. Barnes, F. A. Lockwood, and George Richter.

Printing Industries Papers Available

THE A.S.M.E. Printing Industries Division has issued a pamphlet containing the papers and discussions presented at the Fourth Conference of the Technical Experts in the Printing Industry, held last June at the Semi-Annual Meeting of the A.S.M.E., Chicago, Ill. The papers included in the pamphlet are as follows:

"Value of a Technical Conference." Opening address by Floyd E. Wilder, chairman, Printing Industries Division, A.S.M.E.

"Printing Progress." A comprehensive committee report summarizing the progress and developments of the past year.

"Printing Progress and Labor," by Maj. Geo. L. Berry, president, International Printing Pressmen's and Assistants' Union.

"Program of Cooperative Printing Research in America," by Arthur C. Jewett, Carnegie Institute of Technology.

"An Analysis of Printing Research," by Dr. Henry D. Hubbard, Bureau of Standards.

"Press Drive and Control for Modern Presses," by Joseph Ridder, New York *Journal of Commerce*, with discussion by Hans J. Luehrs.

"Improved Printing Results From Air Conditioning." Prepared by the Cuneo Press, Inc.

"Rubber Rollers, Their Uses and Care," by Harry B. Adsit, mechanical superintendent, Pittsburgh *Post-Gazette*.

Members registered in the A.S.M.E. Printing Industries Division will receive one copy of this pamphlet without charge. Others may obtain copies from the Publication-Sales Department, A.S.M.E., 29 West 39th Street, New York, N. Y., at a price of $0.75 per copy.

1932 Report on Oil Engine Power Cost

THE A.S.M.E. has replenished its supply of the 1932 Oil Engine Power Cost report of the Oil and Gas Power Division, which was originally presented last August at the National Meeting which the division held at Atlantic City. This report will also be published in the April, 1934, issue of the A.S.M.E. Transactions. Copies at a price of $0.90 each may be obtained by addressing the Publication-Sales Department, A.S.M.E., 29 West 39th Street, New York, N. Y.

Coming Meetings of A.S.M.E. Local Sections

Akron-Canton: April 12. Canton, Ohio. (Place to be announced later.) Dinner at 6:30 p.m.; meeting at 7:00 p.m. Subject: "The Rôle of the Engineer," by Dr. Wm. E. Wickenden, President, Case School of Applied Science.

Florida: April 12, 13, 14. Joint meeting with the Florida Engineering Society at the George Washington Hotel. George H. Smith, of Jacksonville, is in charge of the program.

Metropolitan: April 10. Inspection trip to Radio City at 7:30 p.m. Meet at Room 1101, Engineering Societies Building, N. Y. C.

April 19. New York University. Eastern Aeronautic Division. Meeting and inspection of Guggenheim Laboratories.

April 23. Auditorium, Engineering Societies Building at 8:00 p.m. President Paul Doty will address the members of the Society and guests.

New Britain: April 4. New Britain, Conn. Subject: "Small Tools."

Philadelphia: April 24. Engineers' Club, 1317 Spruce St., Philadelphia, at 8:00 p.m. Subject: "Transportation Developments."

Pittsburgh: April 13. Joint meeting with the Engineers' Society of Western Pennsylvania, in the Cardinal Room of the William Penn Hotel, Pittsburgh, at 8:00 p.m. Program arranged through the courtesy of the A.S.M.E. Iron and Steel Division. Subject: "Electrical Control Devices of Special Interest to the Steel Industry," by H. A. Winne, Industrial Engineering Department, General Electric Co., Schenectady, N. Y.

Providence: April 3. A speaker has been obtained from the Union Switch & Signal Co., whose subject will be announced later.

Candidates for Membership in the A.S.M.E.

THE applications of each of the candidates listed below is to be voted on after April 25, 1934, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the Secretary of the A.S.M.E. at once.

In addition to the names given are a group of approximately 1350 transfers from Student to Junior membership, whose names will appear on the ballot for May 15.

NEW APPLICATIONS

BARRY, WILLIAM B., Dallas, Tex.
BRENNER, IVAN G., Canal Winchester, Ohio
CASE, MELVILLE C., Buffalo, N. Y.
CRAFTS, IRVING M., Portland, Conn.
CURIONI, SALVATORE M., New York, N. Y. (Rt & T)
Dow, G. L., Chicago, Ill.
FITCHETT, FREDERICK, Rugby, England
GARBER, O. A., St. Louis, Mo.
GARDNER, ROBERT J., Bridgeport, Conn.
GIBBS, F. O., Greensboro, N. C.
HETTRICK, A. B., Piney River, Va.
HEYMAN, SAMUEL N., Detroit, Mich.
HOLLISTER, S. C., Lafayette, Ind.
HUGHES, RAYMOND M., Detroit, Mich.
JOHNSON, H. A., Oak Park, Ill.
MCGUIRE, DONALD E., Wyandotte, Mich.
MERRING, HARRY L., Astoria, L. I., N. Y.
MORRISH, MURRAY, Highland Creek, Ont.
NASH, RICHARD L., Swissvale, Pa.
NESBITT, HUGH, Mendham, N. J.
NOBLE, GEORGE, Sarnia, Ont., Canada
OBER, T. M., Portland, Oregon
OHLER, RALPH E., Sugar Creek, Mo.
PAULSON, RUDOLPH M., College Point, L. I., N. Y.
PHARO, EDWARD W., JR., Kingston, Pa.
RAUB, J. HEARTT, Cambridge, Mass.
RITTER, PAUL A., JR., Houston, Tex.
ROGERS, PAUL K., New Britain, Conn.
ROGERSON, J. B., El Dorado, Ark.
ROSS, KENNETH A., Vancouver, B. C., Canada
SIMON, WALTER, Berkeley, Calif.
SMITH, BENNIE, Memphis, Tenn.
SUTHERLING, VIRGIL M., Hoquiam, Wash.
THOM, GEORGE B., Bethlehem, Pa.
TRUEDSSON, GOSTA R., Hartford, Conn.

CHANGE OF GRADING

Transfers from Associate-Member

FRANK, PHILIP E., Natural Rock, Ky.
WADE, W. A., Port Elizabeth, South Africa

Transfers from Junior

ASHCROFT, A. G., White Plains, N. Y.
BLAKE, W. G., Woodside, L. I., N. Y.
HARRIS, HORACE WALTER, Forest Hills West, L. I., N. Y.
MEIXELL, K. HAROLD, Jackson Heights, L. I., N. Y.
SINNETT, JOHN B., Ft. Wayne, Ind.
WOOD, JOHN L., Oakhurst, N. J.

A.S.M.E. Transactions for March, 1934

THE March issue of the Transactions of the A.S.M.E., which, under the new plan approved by Council at its December, 1933, meeting, will combine all of the sections previously issued independently and which is being sent to every member in good standing now registered in any of the professional divisions, contains the following papers:

Allowable Working Stresses Under Impact (APM-56-1), by N. N. Davidenkoff

Stability of Thin-Walled Tubes Under Torsion (Abstracted), by L. H. Donnell

Influence of Lashing and Centrifugal Force on Turbine-Blade Stresses (APM-56-2), by R. P. Kroon

The Effect of Openings in Pressure Vessels (APM-56-3), by J. Hall Taylor and Everett O. Waters

Graphostatics of Stress Functions (APM-56-4) by H. M. Westergaard

The Use of the Wind Tunnel in Connection With Aircraft-Design Problems (AER-56-4), by Th. von Kármán and Clark B. Millikan

Performance of Two 101,000-Sq-Ft Surface Condensers (FSP-56-3), by J. N. Landis and S. A. Tucker

Radiation From Luminous and Non-Luminous Natural-Gas Flames (IS-56-1), by Ralph A. Sherman